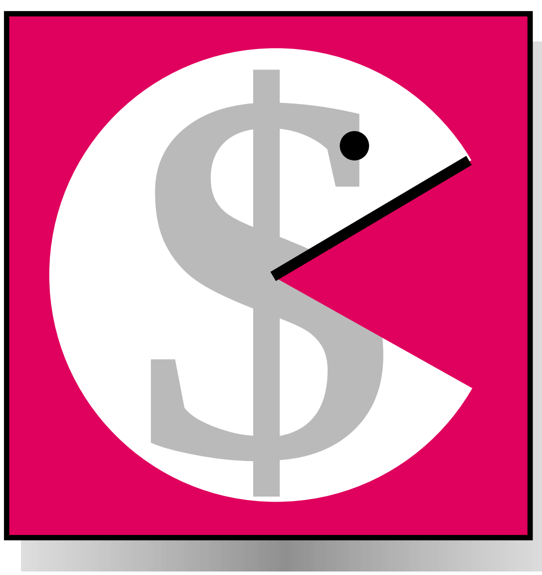
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

IMPROVING THE ENVIRONMENT THROUGH REDUCING SUBSIDIES

Part III
Case Studies



OECD

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Part III: *Case Studies*

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Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, nd which came into force on 30th September 1961, the Organisation for Economic o-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members ubsequently through accession at the dates indicated hereafter: Japan (28th April 1964), inland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary 7th May 1996), Poland (22nd November 1996) and Korea (12th December 1996). The ommission of the European Communities takes part in the work of the OECD Article 13 of the OECD Convention).

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Partie III : Études de cas

Foreword

Improving the Environment through Reducing Subsidies, Part III: Case Studies is the third part of a report to Ministers on a wide-ranging study of the effects of subsidies and tax disincentives to sound environmental practices in various economic sectors and the costs and benefits of their elimination or reform. The first two parts were published together as *Improving the Environment through Reducing Subsidies, Part I: Summary and Conclusions* and *Part II: Analysis and Overview of Studies*. These reports were written in response to a request by the OECD Council at Ministerial level on 21 and 22 May 1996 that the OECD undertake an "analysis of the elimination or reform of environmentally-harmful subsidies".

The eight case studies presented in this volume analyse the effects of particular support schemes in OECD countries, and/or the possibilities for their reform. They have benefited substantially from the comments of participants to the OECD *ad hoc* Meetings of Experts on Subsidies and Environment, who were also responsible for overseeing the work of the overall project.

The book is published on the responsibility of the Secretary-General of the OECD. The views expressed are those of individual contributors, and they should not be interpreted as representing the views of either OECD Member countries or the OECD Secretariat.

Executive Summary

Improving the Environment through Reducing Subsidies: *Part* III, *Case Studies*, is the third volume of a report to Ministers on a wide-ranging study of the effects of subsidies and tax disincentives to sound environmental practices in various economic sectors and the costs and benefits of their elimination or reform.

This volume comprises eight case studies which analyse the effects of particular support schemes in OECD countries, and/or the possibilities for their reform. They serve as additions to the vast empirical research related to the environmental effects of support measures, investigating in more depth the different aspects of the mechanisms that determine the various ways support measures may affect the environment. They aim at expanding understanding of a number of analytical issues, namely:

– *the joint effects of support measures and taxation*;
– *how support measures or taxes influence prices and costs*;
– *identifying decisive factors in support and taxation regime*;
– *how support, particularly to energy, influences downstream costs*; *and*
– *implementation issues.*

In addition to providing valuable insight into the policy relevant support issues in each of the sectors under consideration, the studies also underpinned a number of general conclusions which were not easily drawn from other, previous, work on subsidisation. The most important ones are:

– Support measures and taxation should be taken into account simultaneously. Analytically, the same support measure applied in different taxation regimes will have strongly different effects on marginal costs, depending on (other) elements of the taxation regime. International comparisons of support measures which do not consider the particular local circumstances may therefore be misleading.
– In addition, politically, the relative competitiveness of industries is often influenced more strongly by differences in the normal rates of taxation than by particular forms of support, with the latter sometimes being in place to mitigate the effects of normal rates of taxation.

– Reform of support must be carried out with care, but, when this is done, it can result in both environmental and economic gains. Due attention must be given to the nature of the support, and the conditions for its removal.
– The removal of support, however, will not always lead to a reversal of any negative environmental effects encouraged by the support measure. This is particularly the case where support is capitalised into production factors, such that its removal at a later stage may not lead to a reduction in the incentives to undertake the environmentally-damaging activities.

Table of Contents

List of Tables

List of Figures

Effects of Government Subsidies on the Environment: the Case of Electricity and Newsprint Production from a Swedish Perspective

Environmental and Economic Effects of Support to the Austrian Pulp and Paper Industry

Introduction

The case studies described in this volume serve as additions to the vast empirical research related to the environmental effects of support measures. They investigate in more depth different aspects of the mechanisms that determine the various ways support measures may affect the environment. They aimed at expanding understanding of a number of analytical issues, namely:

a) T*he joint effects of support measures and taxation*. Many previous case studies have focussed only on the effects of support measures, without taking into account the interdependencies between support measures and the prevailing taxation regimes. This leads to incomparable and even misleading results, especially when analysing support measures in an international context.

b) H*ow support measures or taxes influence prices and costs*. In the context of the analytical framework adopted for this project, it was found to be necessary to analyse in some detail how support measures influence prices and marginal costs. These can be used as explanatory variables for the economic effects support measures and their reform or removal might have on the economy.

c) I*dentifying decisive factors in support and taxation regimes*. Support measures and taxation regimes differ significantly between countries. By re-analysing a number of previous case studies on support to energy, focusing this time on the decisive factors of the support regimes, it was possible to formulate more general conclusions about the environmental effects of support policies or their reform. Estimating the effects of various taxes and support measures to transport also identified the importance of their effects on marginal costs.

d) H*ow support, particularly to energy, influences downstream costs*. Although quite a number of case studies which usie empirical economic models take upstream and downstream effects into account, it was felt that it would also be useful to adopt a more bottom-up approach to the analysis, allowing for the incorporation of more detailed economic and technical data.

e) I*mplementation issues*. Because support reform or removal is often opposed based on a perceived or real fear of a loss of competitiveness, a case study was commissioned to look into the possibility of prisoners' dilemma situations in such cases. Another study looked into the possibilities for reforming support measures in such a way that both the economy and the environment would benefit.

While all case studies fall more or less into all of the above categories, Table 1.1 lists them according to their **main** focusses.

Table 1.1. **Overview of case studies**

Case studies	Topics addressed				
	Joint effects of support measures and taxation	Effects on prices and costs	Decisive factors and empirical results	Effects on downstream costs	Implementation issues
CHEN, D., "The Effects of Taxes and Support on Marginal Costs: Quantitative Illustrations"	•	•			
RAINELLI, P. and VERMERSCH, D., "Environmental Impacts of Agricultural Support: Cereal Irrigation in France"		•	•		
HELMING, J. and BROUWER, F., "Environmental Effects of Changes in Taxation and Support to Agriculture"		•	•		
PILLET, G., "Effective Tax Rates on the Marginal Costs of Different Modes of Freight Transport"	•	•	•		
VOLLEBERGH, H., "Energy Support Measures and their Environmental Effects: Decisive Parameters for Subsidy Removal"			•		•
NORMANN, G., FRITZ, P. and SPRINGFELDT, P., "Effects of Government Subsidies on the Environment: the Case of Electricity and Newsprint Production from a Swedish Perspective"			•	•	
OBERSTEINER, M., NILSSON, S. and WÖRGÖTTER, A., "Environmental and Economic Effects of Support to the Austrian Pulp and Paper Industry"					•
VERBRUGGEN, H. and OOSTERHUIS, F., "Competitiveness and Reduction of Support Measures to Industry: the Prisoners' Dilemma"			•		•

1. OVERVIEW OF THE CASE STUDIES

CHEN, "The Effects of Taxes and Support on Marginal Costs: Quantitative Illustrations"

This study analyses the how differences in taxation regimes affect the impacts of identical support measures on marginal costs, using a Marginal Effective Tax Rate (METR) approach. Starting from two hypothetical taxation regimes (differing in the relative weights of labour, capital, and other taxes, and assuming a Cobb-Douglas production function), the study examines the effects of an identical support measure applied in each of these taxation regimes on marginal costs. Significant differences in the effects on marginal costs are found in the different taxation regimes, leading to the important policy conclusion that any comparison of support measures in countries that have different taxation regimes must take these differences into account. This is particularly true given that a change in the level of subsidisation can lead to changes in the amount of taxes required to fund the support.

RAINELLI and VERMERSCH, "Environmental Impacts and Agricultural Support: Cereal Irrigation in France"

This study analyses how changes in European Union support policies in 1992 affected irrigation practices in France. The relevant policy changes included a reduction in the intervention price of cereals (the market price support), and an associated compensation to farmers in the form of direct area payments.* The compensation payments are based on farm size and regional yields, and are subject to set-aside conditions. As a result, this scheme uses direct income payments which are dependent on the past relative prices and agricultural practices used by each farm. Thus, the payments capture the value of any intensive farming practices that were used (particularly irrigation) in the value of the compensation paid to the farm, and therefore in the value of the farmland. This provides an incentive to farmers to maintain high marginal productivity levels on these lands, locking-in the use of irrigation water on those farms where its previous use had led to high yields, and which are now reflected in the compensation payments. Thus, one of the outcomes of the support scheme has been to induce further irrigation, and the complementary use of fertilizers. Thus, instead of leading to agricultural extensification, this compensatory measure has resulted in an increase in environmentally-damaging farm practices instead. Although the policies represent a move towards direct income payments, by linking them to past levels of production and profit they provide no incentive to reduce the environmentally-damaging practices that were taking place under the previous market price support scheme.

* Similar policies were already underway in France, but were enhanced by the European Union changes.

While in general a switch from market price support to direct income payments will both benefit the environment and lead to a higher transfer efficiency of the support itself, such measures need to be carefully formulated so that any potential environmental benefits are realised.

HELMING and BROUWER, "Environmental Effects of Changes in Taxation and Support to Agriculture"

This study uses a regionalised, comparative static partial equilibrium model, under the assumption of infinite price elasticities of agricultural outputs and purchased inputs, to analyse the effects of changes in the relative prices of nitrogen inputs in agriculture on the use of the inputs and nitrogen emission levels in the Netherlands. The analysis found striking differences between the different nitrogen taxation scenarios with respect to their effects on both the resulting nitrogen levels and gross profit margins for the various livestock and crop sectors examined. As economic theory would suggest, it was found that a tax on nitrogen surpluses (*i.e.*, an emissions tax) is a more efficient policy tool for reducing nitrogen usage in agriculture than the taxation of nitrogen-rich fertilizer or food concentrate inputs, or both. Thus, for a given level of reduction in the margin between revenues and marginal costs experienced by the sector as a result of the taxes, the tax on nitrogen surpluses was found to lead to a larger reduction in nitrogen emissions than the taxes on nitrogen inputs. The study highlights the importance of the various intermediate deliveries of manure and fodder between livestock crop production and agribusiness activities, resulting in strong interdependencies between these sectors within agriculture. Implicitly, the spatial dimension, both in terms of the distances between the activities, and the differences in the assimilative capacity of the local environment, plays an important role.

This study and the one by Rainelli and Vermersch one can be seen as complementary to each other. While the Rainelli and Vermersch study examined how changes in agricultural support policies affected the use of irrigation water and intensive farming techniques (the production function) at the farm level, Helming and Brouwer concentrated on the links between various subsectors of the agricultural production system through an examination of how the intermediate deliveries between them are affected by changes in the relative prices of nitrogen-based inputs.

PILLET, "Effective Tax Rates on the Marginal Costs of Different Modes of Freight Transport"

This study set out to analyse the degree to which transfers conditional on specific inputs (labour, capital, or fuel), as well as user charges in four European countries (Germany, France, The Netherlands and Switzerland) vary in their effects on the marginal costs of different modes of freight transport (road, rail, air and inland shipping (where appropriate and where data were available). The study applied a METR approach comparable to the method used in the study by Chen, calculating the effects of an inventory of road taxes and charges for the four European countries under examination on the marginal costs of a standardised haul of 40 tons over 500 kilometres. As such, the study also serves as an exploration of a potentially useful yardstick for comparing the effects of government transfers on the relative competitiveness of different modes of freight transport in various countries.

The results revealed large differences in the marginal effective tax rates between the neighbouring countries for all modes of transport. What is more relevant for analysing the potential environmental effects of changes in taxation is that large differences in the METRs were found between the different modes of transport within each country as well. Rail freight was found invariably to be taxed relatively lightly (probably in comparison to other economic activities as well), road freight was taxed relatively highly (but probably not more heavily than other economic activities), and air freight was taxed somewhere between road and rail. (It is likely that a more comprehensive analysis of inland and sea-borne shipping would also have shown relatively low marginal effective tax rates for these freight transport modes.) Rather unexpectedly, the study also found that differences between countries were explained to a larger extent by differences in labour taxation, rather than differences in fuel taxation or user charges.

VOLLEBERGH, "Energy Support Measures and their Environmental Effects: Decisive Parameters for Subsidy Removal"

This study re-analyses a number of previous case studies (that differed considerably in their scopes and methodologies (and applies a common analytical framework to them to reveal the decisive factors of support regimes to energy. The study set out to define more generalised conclusions from these previous case studies. It distinguished between the *i*) characteristics of support measures (support to producers or consumers and the points of impact of the support and other regulations that might interfere with the support measures); *ii*) characteristics of the recipient sectors (demand and supply conditions, input shares and substitution elasticities); and *iii*) the differences in circumstances that determine the benchmark case (to what extent present and expected regulations and autonomous changes in technology and economy are already assumed).

The findings of the study underlined: *i*) the importance of potential fuel switches on the effects of support reform or removal and, consequently, how support to electricity generation and industrial energy use is likely to have stronger effects than support to household use; and *ii*) that support to fossil fuels, especially to coal, is likely to be less effective (*e.g.* in terms of maintaining employment) if at the same time stricter environmental standards are introduced and when new technologies emerge. Thus, maintaining support to fossil fuels under these circumstances will have small (positive) effects on employment, while still having significant (negative) effects on the environment.

NORMANN, FRITZ and SPRINGFELDT, "Effects of Government Subsidies on the Environment: the Case of Electricity and Paper Production from a Swedish Perspective"

This study investigates how the level of newsprint production and the processes used, with their associated air emissions, would change if the electricity producers and the newsprint industry were obliged to pay the same CO_2 and electricity tax rates as other sectors of the Swedish economy. These exemptions exist to protect Swedish industry against competitors from countries where such taxes are levied at lower rates or do not exist at all.

The study finds that the effects of the increase in taxation on the short-run marginal costs of electricity production would be quite significant, with the METR (or rather the marginal effective rate of policy impact, since effects of regulations are included) estimated to increase by almost 70 per cent. Such a policy would lead to a decrease in the profitability and competitive position of Swedish newsprint production, though more so for the energy-intensive production process (TMP) than for the less energy-intensive one (DIP). Overall, Sweden would be expected to lose a significant proportion of its newspaper production to producers in other countries. This would lead to reduced energy demand in Sweden, which, at the margin, is supplied by relatively highly-polluting oil and coal-fired plants from the integrated Nordic electricity market in most cases.

If the newsprint production would be shifted primarily to countries who use the TMP production process fuelled by particularly polluting electricity production compared with the Nordic production it replaces, the global environmental emissions (particularly of SO_2 and NO_x) might increase as a result of the shift. In spite of the fact that some of these emissions would reach Sweden, total emissions in Sweden would fall. If newsprint production shifted to densely populated countries such as France, Germany and Great Britain, and the DIP process was used fuelled by combined cycle gas turbines (CCGT) instead, global emissions would be expected to fall.

Among the factors determining the potential environmental impact of the policy change are the effects of increased energy taxation on the marginal effective tax rate on energy use and the significant difference in energy intensity of the two alternative processes. Even more important, however, was the assumptions used about both the environmental effects of the production processes in other countries and the openness of the Swedish economy.

The study illustrates the need to analyse changes in support or taxation regimes at the margin, and to estimate both the short- and medium-term effects. It also indicates the existence of a prisoners' dilemma situation in this sector.

OBERSTEINER, NILSSON and WÖRGÖTTER, "Environmental and Economic Effects of Support to the Austrian Pulp and Paper Industry"

This study analyses the economic and environmental effects of the reform of support to the Austrian pulp and paper industry (PPI). The study describes the characteristics of the support, distinguishing between three periods: the first covers the period during which the support was aimed primarily at maintaining certain levels of employment; the second covers the years when environmental improvements were central; and the third covers the most recent period during which market based instruments for environmental policy are increasingly taking the place of support measures in fostering technical change. The study highlights the inefficiencies of particularly the first phase, *inter alia* giving some examples of leakage effects, and the rather sharp increase in total expenditure levels during that phase. The study describes the significant improvements that resulted from the redirection of the support regime, particularly in terms of decreased pollution burdens, improved international competitiveness, and innovation-led export increases of other branches of industry. During the second and third phases, total support to the Austrian PPI declined significantly. The study gives a qualitative assessment of the relative importance of the points of impact of support measures, and of the economic and environmental effects of support to energy for the Austrian PPI.

VERBRUGGEN and OOSTERHUIS, "Competitiveness and Reduction of Support Measures to Industry: the Prisoners' Dilemma"

This study analyses two conditions under which prisoners' dilemma situations occur. The first condition, that a country would be worse off if the support would be removed unilaterally (and better off if all countries would follow such a policy), often does not hold in practice. The second condition arises if the adoption of a policy of support removal to certain industries by all countries would leave some countries (notably those that only import the commodity) worse off, in spite of increasing the overall welfare of all the countries together. The study reviews the occurrence of prisoners' dilemmas in the trade in agricultural products, ferrous and non-ferrous metals, energy, and paper. In these sectors, it is unusual for both the necessary conditions for a prisoners' dilemma to hold with respect to the support of national industries. Often the first condition may be violated because the individual country could realise a net benefit internally through taking unilateral action to reduce support, although it may not be apparent politically that such a net benefit would be realised. The first condition may, however, hold true if the policies of the country would affect world market prices. With respect to the second condition, there are often strategies that can be negotiated at the international level, including either proceeding without the losers if net benefits can still be realised through such action, or the use of side payments or sanctions to induce the "losers" to co-operate. The study draws attention to the common occurrence of *perceived* prisoners' dilemmas. These may arise where the interests of the industry that receives the support are defended by powerful lobby groups. Where these do occur, it appears as if the country as a whole will suffer a welfare loss if the support is removed. The study stresses the difficulty in predicting true prisoners' dilemma situations due to the fact that many of the investigated industries operate on various (niche) markets, where changes in support may have far less immediate effects on competitiveness than they otherwise would.

The Effects of Taxes and Support on Marginal Costs: Quantitative Illustrations

by Duanjie Chen, University of Toronto, Canada

1. INTRODUCTION

This study sets out to illustrate what factors have decisive effects on the marginal effective tax rates on the cost of producing metals[1] and how these factors interact. In particular, the interaction between support and taxation regimes is examined. A hypothetical scenario, with two tax regimes and four industries is used. The two jurisdictions are Countries A and B, representing two different types of tax/support regimes. Country A is a jurisdiction with a generally low tax rate and no industrially-biased capital-based support. In contrast, Country B symbolises a jurisdiction with generally high tax rates and significant capital-based support favouring primary resource producers. The four industries examined are mining, recycling, public utilities and manufacturing. All their production processes use four major inputs of capital, labour, energy and materials, although, of course, in different proportions. The basic assumption is that manufacturers produce the metal by using either primary material provided by the mining industry or secondary material from the recycling industry. Both processes will consume energy, mainly in the form of electricity supplied by the utility sector, but with the primary-material process consuming a substantially higher level of energy than the secondary-material process, at a ratio of 5 to 1.

Our report consists of six sections. After this introduction, Section 2 explains the statutory provisions in taxation and support. Section 3 provides all the non-tax parameters that affect the marginal effective tax rate (METR) estimates, such as economic depreciation rates, capital investment structures, and the production input structures. Section 4 reports the METRs for each of the three pre-manufacturing products produced by mining, recycling, and public utility sectors (*i.e.*, primary material, secondary material, and electricity), assuming that there is no up-stream stage before these production processes.[2] Section 5 simulates the METR on the cost of the metal produced by the manufacturing industry in a regime with low taxes and no industrially-biased capital-based support, *i.e.* Country A. The simulation covers two processes – primary and secondary production – under nine scenarios, with each having a different combination of tax shifting factors on the material pricing and the energy tax/support. The same simulation is carried out in Section 6 for Country B, a regime with higher taxation rates and capital-based support favouring resource producers. Finally, Section 7 draws together the main conclusions of the study. Formulas and the full methodology are given in an annex.

2. STATUTORY TAXES AND SUPPORT

All the numbers presented in this study are the result of combining real data on as many OECD Member countries as could be collected during the limited time available. This data was used to construct "stylised facts" on both the taxation regimes and the cost profiles, enabling estimates to be made of the potential range of marginal effective tax rates for a number of hypothetical cases. Therefore, none of our numbers is drawn directly from any specific country's tax lawes, but instead is a combination of a number of real sources. Furthermore, for simplicity, we avoid any details in the tax classification. For example, there are three major taxes on capital – income tax, property tax, and capital tax. But in our study we consider only the income-related taxes, while ignoring the others. Another example discussed below is that payroll-based taxes vary from country to country in terms of tax bases, rates, and whether they are earmarked for different public expenses. For illustrative purpose, we only need to present a single rate on the same tax base, *i.e.*, the average amount of payroll. Table 2.1 provides an overview of the statutory tax provisions.

Table 2.1. **Statutory tax and support rates**

	Country A	Country B
Tax on capital		
Corporate income tax	40%	50%
Mining income allowance	0%	30%
Mining tax/royalty	15%	0%
Capital cost allowance		
Buildings	5%	4%
Machinery	30%	28%
Depletable	100%	100%
Tax on Labour		
Payroll taxes	12%	30%
Tax on material	VAT	VAT
Support to energy	Up to 40%	Up to 40%
Inventory accounting method	*FIFO*	*FIFO*

2.1. Capital Taxes

Table 2.1 presents two taxes on capital - corporate income tax and mining tax. The latter is also referred to as mining royalty in some jurisdictions and is in fact an economic rent on natural resources. As the table shows, Country A imposes a general corporate income tax of 40% and a mining tax of 15%. It does not provide any special allowance for mining profits. Country B has a higher corporate income tax of 50%, but gives the mining industry a 30% allowance. There is no mining tax or royalty in Country B.

The major tax expenditure relating to the corporate income tax is the capital cost allowance (CCA), or tax depreciation rate. This has to do with how quickly multi-year assets can be written off from taxable income. For illustration purposes, we assume that the CCA rates for buildings and machinery are the same across industries. In particular, in Country A, the tax depreciation rate is 5% for structures and 30% for machinery across all industries. In country B, the rate is 4% and 28% respectively. The tax depreciation rates are slightly higher in Country A than Country B as it is common that regimes with higher tax rates generally provide lower CCA rates. It should be noted that, with respect to a given *economic* depreciation rate, the higher the *tax* depreciation rate, the more generous the tax expenditure is on capital investment. We will come back to this point in Section 2.3 when information is provided on economic depreciation rates and in the analysis of the METR results in later sections.

2.2. Labour taxes

There are generally two main labour taxes: personal income tax and social security taxes. The latter can be further categorised into unemployment insurance (UI) premiums, pension plans, health insurance and other payroll taxes. Based on an assumption that employers bear the full cost of their statutory share of payroll taxes, only the average aggregated payroll tax rate payable by the employer is presented in Table 2.1. Again, for simplicity, it is assumed that all the payroll taxes are levied on the full payroll amount. As Table 2.1 shows, the aggregated payroll tax rate payable by an employer is 12% of the payroll in Country A and 30% in Country B.

2.3. Tax on material

As value-added tax (VAT) has become a popular form of sales tax in most OECD countries, we assume that both Countries A and B impose a VAT on transactions. As a result, materials as an input to any production process will bear virtually no sales taxes. Therefore, Table 2.1 does not present any specific statutory sales tax rate on materials.

In relation to material inputs and, in many cases, products in stock, the mandated inventory accounting method affects the tax that is payable in a rapid price-changing period. There are mainly two accounting methods for writing off the cost of inventory for tax purposes. They are "first in first out" (FIFO) and "last in first out" (LIFO). When inflation is high and the capital share in inventory is large, FIFO can penalise firms by taxing profits that are derived not from ongoing operations but by the artificially low cost of goods sold (resulting from the sale of inventory which is now much more expensive to replace). Similarly, the LIFO approach can increase the tax burden if the price of inventory is dropping rapidly. To minimise the inflation impact on our METR estimates, we assume both Country A and B adopt FIFO.

2.4. Tax/support on energy

Energy, mainly in the form of electricity, comprises another key input to the production processes of manufacturing industries. As mentioned, we use the public utility sector as a proxy for energy suppliers for all the relevant data, including cost structures and tax provisions. The difficulty in presenting a standard description of statutory tax/support systems in relation to power suppliers lies in the varied ownership of the electricity-generating assets. That is, industrially consumed electricity may be supplied by either investor-owned electricity generators (IOE) or government-owned electricity generators (GOE). The cost of producing this power can differ by a large margin between the two different ownership structures.[3] IOEs compete with other firms for capital, labour, and materials in the market and are subject to the government taxation discussed above. They bear market risks and must compensate investors for this risk in the form of higher interest rates and/or returns to equity. In contrast, GOEs have to compete with other firms for labour and materials, but not for capital. In addition, they do not pay income taxes. As energy support has already been studied intensively, we do not intend to go into details on this matter. Instead, we simply assume three cases in our study. First that IOEs are taxed in the same way as any other non-government-owned firms. For this case, a METR on IOE's production costs will be estimated. Second that GOEs sell energy at lower prices than market price to large consumers in the manufacturing industry. For this case, 40% is chosen as an arbitrarily specified support rate. The third case is simulated only for comparison purposes and assumes that there is neither a tax nor support applicable to energy pricing.

3. NON-TAX PARAMETERS: ECONOMIC DEPRECIATION RATES, CAPITAL AND INPUT STRUCTURES

Besides the statutory tax provisions, there are some non-tax parameters that affect the METR estimates significantly. As presented in Table 3.1, they are mainly

Table 3.1. **Non-tax parameters**

	Utility	Recycling	Mining	Manufacturing	
				Primary	Secondary
Economic depreciation rate					
Buildings	4.6%	5.2%	5.0%	5.1%	5.1%
Machinery	22.3%	20.9%	12.1%	7.1%	7.1%
Capital structure					
Buildings	56.2%	14.2%	19.1%	35.9%	35.9%
Machinery	23.0%	16.0%	14.0%	32.3%	32.3%
Inventory	18.7%	66.1%	23.4%	30.6%	30.6%
Land	2.0%	3.6%	1.9%	1.2%	1.2%
Depletable	0.0%	0.0%	41.6%	0.0%	0.0%
Input structure for production					
Capital	58.0%	17.0%	37.0%	24.3%	6.8%
Labour	21.0%	52.0%	27.0%	20.6%	5.9%
Utility	1.0%	1.0%	5.0%	13.1%	2.6%
Material	21.0%	30.0%	31.0%	42.0%	84.7%

economic depreciation rates, capital structures, and the input structure of production. As described above, different capital assets and inputs to production are taxed differently in terms of the statutory provisions. As a result, industrially specific economic depreciation rates, capital structures and input structures will result in differentiated METRs on capital and the costs of production across industries.

As Table 3.1 shows, the economic depreciation rate for structures is around 5% for all industries while that for machinery ranges from a low of 7.1% in the manufacturing industry to a high of 22.3% in utilities. As the tax depreciation rate is the same across industries within any taxation regime for the same type of depreciable asset, the industry with the lowest economic depreciation rate will enjoy the most tax support on capital compared to the others. In this study, therefore, the manufacturing industry, followed by mining, obtains the most favourable tax support simply due to its low economic depreciation rate.

In terms of capital structure, the four industries show different features. In the mining industry, depletable assets account for over 40% of the total capital investment, while other industries have zero amounts for depletable assets. Since depletable assets can be written off in the most generous manner (*i.e.*, can be written off as expenses or the like) in many countries, the significantly high share of capital in depletable assets ensures a low METR on capital for mining. Second, inventory takes as high as 66% of total capital employed in the recycling industry. This reflects the inherent structure of the recycling industry. As can be seen in Section 4, inventory, as a non-depreciable asset, is generally taxed higher than certain depreciable assets (for instance, machinery), which have generous tax depreciation rates compared to the economic depreciation rate. Therefore, the very high share of inventory in capital can cause a high METR on capital investment for recycling. Third, the utility industry appears to employ over 56% of capital spending on structures (or "buildings" in our tables), so that the METR on structure will play a major role in its aggregated METR on capital. Finally, besides a small portion on land, the capital employed by the manufacturing industry is spread relatively evenly across buildings, machinery and inventories. As a result, the METR values on these three types of capital will determine the aggregated METR on capital for the manufacturing industry.

The final panel in Table 3.1 provides the input structure for production. As the table shows, the utility and mining industries are capital intensive with capital shares at 58% and 37% respectively. In contrast, recycling is labour intensive with labour inputs accounting for 52% of the production costs. Manufacturing is material intensive but appears to be very different in cost structure between primary and secondary sectors. The primary manufacturing sector consumes the highest level of energy (at 13% of the total production costs) compared to all other industries. The secondary manufacturing sector consumes only a fifth of the energy consumed by the primary sector, but materials make up more than twice as muchl of the share of costs. As the overall METR on the cost of production is determined by the METR on each input weighted by the input share, the industry with the largest (smallest) cost share in the highest (lowest) taxed input will generally incur the highest overall METR. We will see illustrative results along this line in the following sections.

4. METR ON UP-STREAM PRODUCTION

As mentioned earlier, the up-stream producers examined in this study are the mining, recycling, and utility sectors, and there are assumed to be no further up-stream material producers before them.

Table 4.1 reports the METRs on capital by asset type and industry. For comparison, we also include the manufacturing industry. The observations that can be drawn from the table are the following:

1. The METR on capital is generally higher in Country B than in A, but much lower for the mining industry in Country B than A. This is a self-evident result of the difference in statutory tax provisions between the two countries, as analysed in Section 2. That is, Country A imposes lower taxes in general with no special allowance for mining but an extra mining tax or royalty. Country B presents the opposite case – higher general taxes combined with a generous mining profit allowance of 30%.

Table 4.1. **Marginal effective tax rate on capital**

	Utility	Mining	Recycling	Manufacturing
	Country A: Lower taxes and no mining support			
Buildings	35.11%	45.12%	38.98%	38.33%
Machinery	23.62%	8.30%	21.87%	–2.74%
Inventory	28.83%	41.18%	28.83%	28.83%
Land	28.83%	41.18%	28.83%	28.83%
Depletable	NA	–21.99%	NA	NA
Aggregate	**31.17%**	**9.27%**	**29.15%**	**22.04%**
	Country B: Higher taxes with mining support			
Buildings	61.93%	17.74%	68.21%	67.16%
Machinery	42.07%	–8.78%	39.37%	1.49%
Inventory	43.24%	10.18%	43.24%	43.24%
Land	43.24%	10.18%	43.24%	43.24%
Depletable	NA	–34.99%	NA	NA
Aggregate	**53.50%**	**–10.94%**	**46.17%**	**38.34%**

2. Amongst all the types of assets examined, buildings are taxed the highest and machinery the lowest, except for the depletable assets used by the mining industry. Inventories and land are taxed at the same effective rates, at a level somewhere between structure and machinery. This is mainly because machinery enjoys a very generous tax depreciation rate compared to its economic depreciation rate. In contrast, buildings can be written off only at a rate lower than or close to their economic depreciation rates such that the former is not enough to cover the latter in real terms. The negative METR on depletable assets for the mining industry indicates a substantial tax support as depletable assets can be written-off as expenses while they are still generating income. It should be noticed that a negative METR does not necessarily indicate a direct support as the excessive tax write-off for one capital item can be used to offset the tax on another within the same investment.

3. The mining industry is the lowest taxed of all the industries examined. In Country A, the METR on all capital for mining is only 9.3%, half the next lowest METR in the country (22% in the manufacturing industry). This is mainly due to its very high share (42%) of capital in depletable assets, which enjoy a tax support as mentioned above. In Country B, the METR on mining capital is also extremely low, at negative 11%. This is mainly due to the very generous tax allowance for mining combined with the lack of a mining tax or royalty.

4. The manufacturing industry is the second lowest taxed as a result of the generous tax depreciation rate for machinery in relation to the very low economic depreciation rate. The former is 30% and 28% in Countries A and B respectively, while the latter is only 7%. As the share of machinery in capital used by the manufacturing industry is over 30% – the highest amongst all the industries – the very low METR on machinery used by manufacturers is the major contributor to the low aggregated METR on its capital.

5. Utility is the highest taxed industry followed by the recycling industry. This is mainly because the utility sector has over 56% of its capital in buildings, which are the highest taxed asset. As for the recycling industry, the main reason for its second highest METR on capital is its extremely high share in inventory (66%), which is the asset type with the second highest effective tax rate.

Table 4.2 presents METRs on the overall costs of production in the utility, mining, and recycling industries (input industries). For each country, the first row re-displays the METR on capital by industry, and the second one shows the statutory labour tax rate provided in Table 2.1 as the METR on labour. It should be noticed that energy consumed by the utility industry accounts for only 1% of its total costs such that assuming a zero METR on energy used by the utility industry will not affect the final result in any significant way. To simplify the illustration, we assume that the effective tax burden on utility generators is fully shifted on to the mining and recycling industries. Therefore, the METR on the overall costs of the utility sector (*i.e.*, 19.9% for Country A and 35.5% for Country B), is shown as the METR on energy used by the mining and recycling industries. Finally, the utility, mining, and recycling industries are assumed to not use materials supplied from outside, and so materials have a zero METR for all three. The METR on the overall cost of production is estimated using the augmented Cobb-Douglas production function[4] and reflects the combined effect of METRs on each input and the related input share. Figure 4.1 shows the overall METRs for the two different taxation regimes represented in Countries A and B.

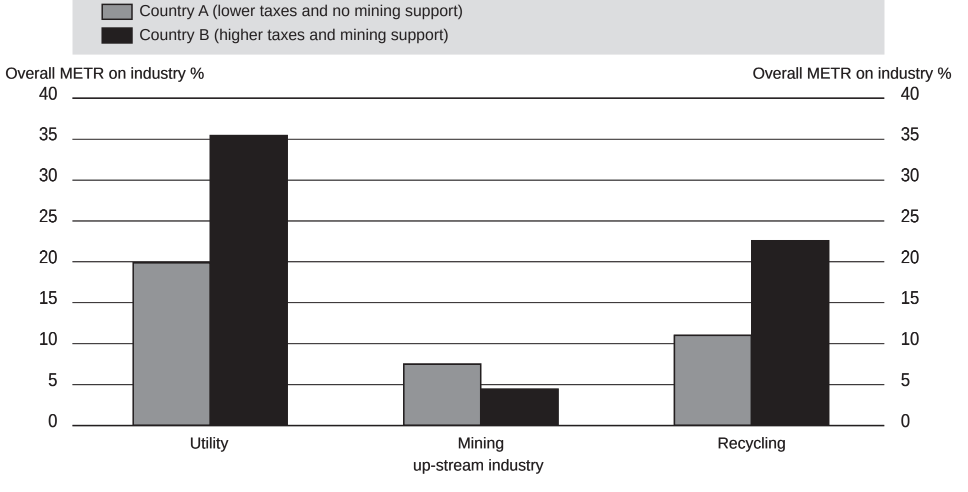
The two major findings are the following:

1. Between the three input industries, mining is the one most favoured by the tax/support regime. This is mainly due to its high capital share in depletable assets, which is expensed for tax purposes. The utility firms, if owned by non-government investors and hence subject to taxes, are taxed the highest due to their extremely high capital share in their inputs (58%), and because their capital is the highest taxed among capitals used by other industries. The recycling industry is labour-intensive (with labour accounting for 52% of total production inputs), and labour is the lowest taxed input other than capital for the mining industry. Therefore, the recycling industry is taxed lower than utility but higher than mining.

Table 4.2. **Marginal effective tax rate on up-stream production**

	Utility	Mining	Recycling
	Country A: Lower taxes and no mining support		
Capital	31.2%	9.3%	29.2%
Labour	12.0%	12.0%	12.0%
Utility	0.0%	19.9%	19.9%
Materials	0.0%	0.0%	0.0%
Overall	**19.9%**	**7.5%**	**11.0%**
	Country B: Higher taxes with mining support		
Capital	53.5%	–10.9%	46.2%
Labour	30.0%	30.0%	30.0%
Utility	0.0%	35.5%	35.5%
Materials	0.0%	0.0%	0.0%
Overall	**35.5%**	**4.4%**	**22.6%**

Figure 4.1. **Overall METRs on up-stream production activities in countries A and B**



Source: Author.

2. Between the two countries, the inter-industry tax bias is less evident in Country A than in Country B. For example, in Country B, the gap between the lowest taxed industry (mining) and the highest (utility) is 31 percentage points. In contrast, the largest gap is only about 12 percentage points in Country A. Again, this is a direct result of the differences in the tax/support regimes between the two countries. That is, Country A imposes lower taxes in general with no special allowance for mining, but an extra mining tax or royalty. Country B presents the opposite case, with higher general taxes combined with a generous mining profit allowance of 30%.

5. METR ON MANUFACTURING COSTS: COUNTRY A

This section provides an analysis of the METR on the cost of the metal produced by the manufacturing industry, using energy and materials, in Country A. As defined in our study, Country A represents a tax/support regime where taxes are generally lower and there is no industrially-biased capital-based support. We will present two groups of METRs, for primary and secondary manufacturing production processes respectively, under simulations of three values of tax-shifting factor and three cases of energy tax/support.

First, we assume that taxes on mining and recycling industries are fully shifted on to the price of primary and secondary materials respectively. Thus, the tax-shifting factor on the material pricing is equal to one. In other words, manufacturers using either primary or secondary materials as their inputs have to bear the taxes paid by the up-stream input suppliers in the mining or recycling industry. Therefore, METRs on the cost of primary and secondary material inputs are the METRs on the cost of the mining and recycling production processes respectively, as shown in Table 4.2. With this unitary tax-shifting factor, Table 5.1 presents the METRs under three different energy tax/support scenarios: *i*) utility taxes are fully shifted on to the energy pricing; *ii*) no utility taxes are shifted on to the energy purchased by manufacturers; and *iii*) a 40% support on energy pricing is granted to manufacturers. It should be noted that these scenarios are not all applied to non-manufacturing industries where utility taxes are always fully borne by the energy users. For example, when we present a 40% energy support, we assume this support is only available to manufacturers, not to miners or recyclers.

As Case I in Table 5.1 shows, when utility taxes are shifted on to energy consumers through energy pricing, the METR on overall costs is 1.4 percentage points higher for primary production than for secondary. This is the combined effect of METRs on the input and the input structure. That is, energy has the second highest taxes of all the inputs, and material has the lowest. As the primary production consumes five times the amount of energy consumed compared to the

Table 5.1. **Marginal effective tax rate on cost of manufacturing recyclable goods**

Country A: Lower taxes and no mining support

Tax-shifting factor on material price = 1

	Primary	Secondary	Dif. in % points
	Case I: with utility taxes fully shifted on to energy pricing		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	19.9%	19.9%	0.0
Material	7.5%	11.0%	3.5
Overall cost	**13.4%**	**12.0%**	**–1.4**
	Case II: with no utility taxes shifted on to energy pricing		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	0.0%	0.0%	0.0
Material	7.5%	11.0%	1.7
Overall cost	**10.8%**	**11.5%**	**0.7**
	Case III: with 40% support on energy price		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	–40.0%	–40.0%	0.0
Material	7.5%	11.0%	3.5
Overall cost	**3.6%**	**10.0%**	**6.4**

secondary production process, while the latter incurs about 85% of its total production cost on materials, primary producers will obviously be faced with a higher tax burden as measured by the METR. Case II assumes that there are no utility taxes being shifted on to manufacturers so that the METR on energy is zero. In this case, with the METR on primary materials 3.5 percentage points lower than on secondary materials, the METR on the overall costs of production becomes lower on the primary production than on the secondary one, but with a gap of only 0.7 percentage points. When the 40% energy support is available to manufacturers as shown in Case III, the METR on overall costs is much lower for primary than secondary manufacturing, by about 6.4 percentage points.

Table 5.2 simulates the same three energy tax/support scenarios under the assumption of a 0.5 tax-shifting factor on material pricing. With only 50% of the taxes on material production shifted on to material pricing, secondary producers are significantly relieved from bearing the taxes on materials that account for 85% of their total production costs. As a result, when there is no energy support (which

Table 5.2. **Marginal effective tax rate on cost of manufacturing recyclable goods**
Country A: Lower taxes and no mining support
Tax-shifting factor on material price = 0.5

	Primary	Secondary	Dif. in % points
	Case I: with utility taxes fully shifted on to energy pricing		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	19.9%	19.9%	0.0
Material	3.8%	5.5%	1.7
Overall cost	**11.7**	**7.3%**	**–4.5**
	Case II: with no utility taxes shifted on to energy pricing		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	0.0%	0.0%	0.0
Material	3.8%	5.5%	1.7
Overall cost	**9.1%**	**6.8%**	**–2.4**
	Case III: with 40% support on energy price		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	–40.0%	–40.0%	0.0
Material	3.8%	5.5%	1.7
Overall cost	**2.1%**	**5.3%**	**3.3**

benefits the primary producers the most), secondary producers enjoy a lower METR on the overall costs of production compared to primary producers, by about 2.4-4.5 percentage points as shown in Case II and Case I respectively. When the 40% energy support is available to manufacturers, as shown in Case III, secondary producers again pay more taxes than primary producers, but by a narrower gap of 3.3 percentage points.

Table 5.3 repeats the same simulations but with a zero tax-shifting factor on the material prices faced by manufacturers. Under this assumption, manufacturers do not have to bear any taxes on the materials they purchase. As the METR on recycling is higher than that on mining, and since material inputs account for a higher share of costs in secondary production than in primary, this zero tax-shifting factor benefits the secondary producers much more than the primary ones. As Table 5.3 shows, with no energy support, the METR on overall costs is significantly lower for secondary producers than for primary ones. The difference between the two ranges from about 5.4 to 7.5 percentage points as shown in Cases II and I. When the 40% energy

Table 5.3. **Marginal effective tax rate on cost of manufacturing recyclable goods**

Country A: Lower taxes and no mining support

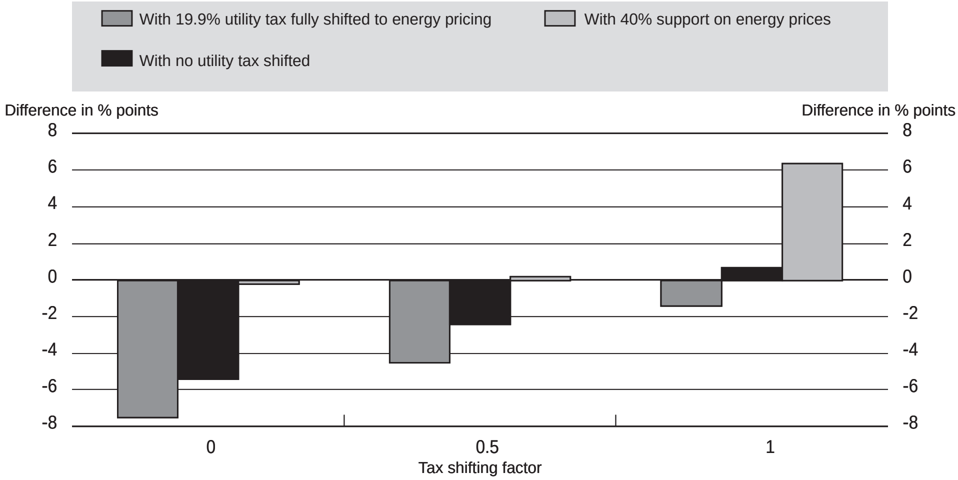
Tax-shifting factor on material price = 0

	Primary	Secondary	Dif. in % points
	Case I: with utility taxes fully shifted on to energy pricing		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	19.9%	19.9%	0.0
Material	0.0%	0.0%	0.0
Overall cost	**10.0%**	**2.5%**	**–7.5**
	Case II: with no utility taxes shifted on to energy pricing		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	0.0%	0.0%	0.0
Material	0.0%	0.0%	0.0
Overall cost	**7.4%**	**2.0%**	**–5.4**
	Case III: with 40% support on energy price		
Capital	22.0%	22.0%	0.0
Labour	12.0%	12.0%	0.0
Energy	–40.0%	–40.0%	0.0
Material	0.0%	0.0%	0.0
Overall cost	**0.5%**	**0.7%**	**0.2**

support is available as shown in Case III, secondary producers again incur a higher METR on overall costs compared with the primary producers, but only by a very small margin of 0.2 percentage points.

In summary, the higher (lower) the up-stream taxes being shifted on to material pricing and the higher (lower) the energy support, the more (less) the secondary manufacturing production is taxed compared to the primary one. This can be seen by comparing the gap in METRs on the overall costs shown in Case III of Table 5.1 and Case I of Table 5.3 with their counterparts in all other cases of Tables 5.1, 5.2 and 5.3 (see Figure 5.1 below). There are three major factors contributing to this result. First, the mining industry (which produces the primary inputs) is taxed significantly lower than the recycling industry (which produces secondary inputs), mainly because of its unique high capital share in depletable assets that can be expensed for tax purposes. As a result, secondary materials are taxed higher than primary materials. When the tax shifting factor is equal to one, this up-stream tax gap is fully shifted on to the difference in manufacturing input taxes. Second, as

Figure 5.1. **Difference in percentage points in METRs on primary and secondary manufacturing in country A under different tax scenarios and with different tax shifting factors**



Source: Author.

primary manufacturing consumes more energy than secondary, a higher energy support will benefit the primary manufacturing industry more, resulting in a lower METR on primary manufacturing costs. Finally, while the primary manufacturing consumes five times the amount of energy of the secondary industry, the secondary manufacturing uses more materials in terms of input shares (85% compared to 42%). This striking difference in input structures further amplifies the effects of the mining-related tax expenditure and the energy support on overall METR differences between the primary and secondary manufacturers.

6. METR ON MANUFACTURING COSTS: COUNTRY B

In contrast to Country A, Country B is a jurisdiction with higher taxes and with a special mining support, but no mining royalty. As analysed in Section 3, compared with Country A this different tax/support regime generally results in a higher METR on capital and the overall costs of production in all up-stream industries except for mining. Obviously, these differentiated up-stream METRs will affect all the simulations for various tax-shifting factor and energy tax/support effects presented in Section 5.

A first glance through Tables 6.1, 6.2 and 6.3 show similar results as observed above for Country A. That is, the higher (lower) the up-stream taxes being shifted on to material inputs pricing and the higher (lower) the energy support, the more (less) the secondary manufacturers are taxed in relation to the primary manufacturers. This can be seen by comparing the gap in METR on overall costs shown in Case III of Table 6.1 and Case I of Table 6.3 with their counterparts in all other cases of Tables 6.1, 6.2 and 6.3.

However, a careful comparison of all numbers in the Table 6s with the Table 5s can indicate more about the two different tax/support regimes. The most noticeable finding is that, while METRs are generally higher in Country B than in A, the METR gaps between primary and secondary productions are widened. As analysed in Section 4, due to the differences in statutory tax/support provisions, the METR gap between mining and recycling production is wider in Country B compared with that in Country A, *i.e.*, 18.2 percentage points compared with 3.5 percentage points (see

Table 6.1. **Marginal effective tax rate on cost of manufacturing recyclable goods**
Country B: Higher taxes with mining support
Tax-shifting factor on material price = 1

	Primary	Secondary	Dif. in % points
	Case I: with utility taxes fully shifted on to energy pricing		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	35.5%	35.5%	0.0
Material	4.4%	22.6%	18.2
Overall cost	**21.0%**	**24.4%**	**3.4**
	Case II: no utility taxes shifted on to energy pricing		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	0.0%	0.0%	0.0
Material	4.4%	22.6%	18.2
Overall cost	**16.3%**	**23.4%**	**7.1**
	Case III: with 40% support on energy price		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	–40.0%	–40.0%	0.0
Material	4.4.%	22.6%	18.2
Overall cost	**8.8%**	**21.7%**	**13.0**

Table 6.2. **Marginal effective tax rate on cost of manufacturing recyclable goods**

Country B: Higher taxes with mining support

Tax-shifting factor on material price = 0.5

	Primary	Secondary	Dif. in % points
	Case I: with utility taxes fully shifted on to energy pricing		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	35.5%	35.5%	0.0
Material	2.2%	11.3%	9.1
Overall cost	**19.9%**	**14.6%**	**–5.3**
	Case II: no utility taxes shifted on to energy pricing		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	0.0%	0.0%	0.0
Material	2.2%	11.3%	9.1
Overall cost	**15.3%**	**13.7%**	**–1.6**
	Case III: with 40% support on energy price		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	–40.0%	–40.0%	0.0
Material	2.2%	11.3%	9.1
Overall cost	**7.8%**	**12.2%**	**4.4**

Figure 6.1). How this wider METR gap between mining and recycling industries may affect the METR gap between the primary and secondary production will depend on the tax-shifting factor on material pricing. When the tax-shifting factor is one, the up-stream tax-gap is fully shifted on to material pricing. Country B's METR gap on material costs (18.2 percentage points), overcomes the energy tax/support effects such that secondary manufacturers always bear higher METRs compared to primary ones, by at least 3.4 percentage points as shown in Table 6.1, Case I.

When the tax-shifting factor is lowered to 0.5, the METR gap on material costs shrinks by 50% to 9.1 percentage points, and the impact of energy tax/support is such that the primary process bears higher METRs for Case I and Case II, while the secondary process does so for Case III, as can be seen in the overall METR. In fact, as the general taxes are higher in Country B, the utility firms, if owned by non-government investors, have to pay much higher taxes than their counterparts in Country A. Therefore, when the tax-shifting factor on material pricing is limited and

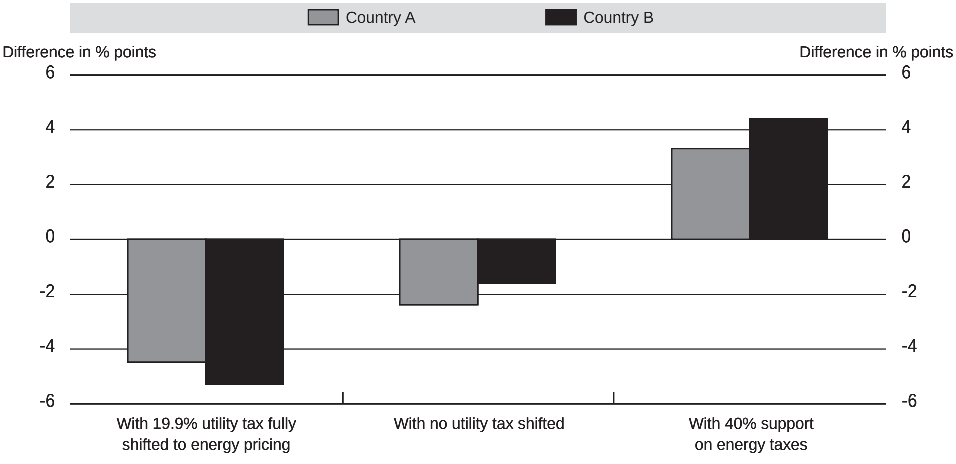
Table 6.3. **Marginal effective tax rate on cost of manufacturing recyclable goods**
Country B: Higher taxes with mining support
Tax-shifting factor on material price = 0

	Primary	Secondary	Dif. in % points
	Case I: with utility taxes fully shifted on to energy pricing		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	35.5%	35.5%	0.0
Material	0.0	0.0%	.0.0
Overall cost	**18.8%**	**4.6%**	**–14.2**
	Case II: no utility taxes shifted on to energy pricing		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	0.0%	0.0%	0.0
Material	0.0%	0.0%	0.0
Overall cost	**14.2%**	**3.8%**	**–10.4**
	Case III: with 40% support on energy price		
Capital	38.3%	38.3%	0.0
Labour	30.0%	30.0%	0.0
Energy	–40.0%	–40.0%	0.0
Material	0.0%	0.0%	0.0
Overall cost	**6.8%**	**2.4%**	**–4.4**

utility taxes are fully shifted on to energy pricing, secondary manufacturers in Country B will enjoy greater tax advantages as compared with primary manufacturers, than their counterparts in Country A will. However, once a 40% energy support is available, the METR gap between the secondary and primary production process will be bigger in Country B than that in Country A (*i.e.*, 4.4 *vs.* 3.3 percentage points as shown in Case III of Tables 6.2 and 5.2).

Finally, when no up-stream taxes are being shifted on to material pricing (*i.e.*, both primary and secondary material inputs are taxed at zero rate), energy tax/support and its differentiated shares in primary and secondary production becomes the dominant factor in the METR gap. As a result, secondary producers can enjoy tax advantages in any of three energy tax/support cases. As can be seen through a comparison of Table 6.3 and Table 5.3, these tax advantages appear to be much more significant in Country B than in Country A.

Figure 6.1. **Difference in percentage points in METRs on overall costs of primary and secondary manufacturing for countries A and B, assuming a tax shifting factor of 0.5**



Source: Author.

7. CONCLUSIONS

Our simulation and analysis show clearly that the METR on the costs of production is determined not only by the statutory tax/support provisions, but also the capital and input structures and the tax-shifting factor.[5]

Based on the above analysis, we can draw the following observations:

1. Generous support to the mining industry places a great tax advantage on primary materials production over recycling. As the up-stream tax bias can be shifted on to the pricing of materials for producing the metal, this mining tax advantage can discourage the secondary production of metals.
2. Second, any energy support will benefit primary manufacturing production more than secondary as the latter consumes less energy than the former.
3. Finally, as the recycling industry is labour-intensive while mining is capital-intensive, a higher labour tax in general will give primary metal industry greater tax competitiveness.

In conclusion, the nature of the prevailing taxation regime, combined with the capital and production-input structure, will have an important effect on relative prices. Furthermore, depending on the prevailing market conditions, upstream taxes and support will generally have an effect on downstream relative prices. As a result, any taxes that encourage resource exploitation and any support that encourages energy consumption will discourage the recycling and secondary production industries as compared to mining and primary production, and hence may be environmentally malign.

Annex

Methodology for Calculating Marginal Effective Tax Rates

This appendix provides formulae and explanations for the METR calculations. For a formal derivation of the formulae, please refer to works by J. Mintz and his colleagues, listed in the references for this report. The formulas are presented in the following order: METR on each input of production, METR on the marginal cost of production, and the tax-shifting factor.

1. The Marginal Effective Tax Rate on Capital

The marginal effective tax rate on capital measures the impact of a tax system on an incremental capital investment. It incorporates not only the effects of investment-related statutory tax rates and other tax treatments (*e.g.*, tax depreciation, tax credits, tax deductibility, tax holidays) but also various economic factors interacting with these tax treatments (such as the financing cost of the inflation rate, and the structure of capital). In other words, the marginal effective tax rate is a summary indicator of the overall tax burden imposed by a tax system on a new investment in a certain economic environment. Numerically, it is a percentage expression of the difference between gross-of-tax rate of return on the capital and net-of-tax rate of return on capital divided by the net-of-tax rate of return on capital.

The standard method used to estimate marginal effective tax rates has been extensively documented.[6] The formula based on this method has been modified by incorporating some miscellaneous taxes such as those on capital, property, and property transfers.[7] The following are general formulas.

i) *Marginal effective tax rate* (t)

As mentioned above, the marginal effective tax rate, t, on a given type of capital is defined as the proportional difference between the gross-of-tax rate of return (r^G) and the net-of-tax rate of return (r^N). That is:

$$t = (r^G - r^N)/r^N \qquad (1)$$

r^N is the weighted average of the return to debt and equity securities required by the financial investor. r^G is the difference between the marginal revenue product (or user cost, in equilibrium) and economic depreciation. As shown below, one of the main components of r^G is the real cost of financing, r^f.

ii) *The net-of-tax rate of return on capital* ($\mathbf{r^N}$)

The formula for net-of-tax rate of return, r^N, is:

$$r^N = \beta i + (1 - \beta)\,\rho - \pi \qquad (2)$$

This is the rate of return on capital required by suppliers of investment funds.

iii) ***The real cost of financing*** (r^f)

The real cost of financing (r^f) is defined by:

$$r^f = \beta i\,(1 - U) + (1 - \beta)\,\rho - \pi \tag{3}$$

with β = debt to assets ratio; i = cost of debt; U = the statutory corporate income tax rate which indicates, in the formula, the interest deductibility for corporate income tax purposes; ρ = the cost of equity; and π = the inflation rate. That is, the cost of financing for a real capital investor is the weighted average cost of financing net of the inflation rate.

iv) ***The gross-of-tax rate of return*** (r^G) ***on capital***

a) Depreciable assets

$$r^G = (1 + t_s)(r^f + \delta + h)(1 - k)\,[1 - A + \iota\,(1 - U)/(\alpha + r^f + \pi)]/[(1 - U)(1 - tg)] + tp/(1 - tg) - \delta - h \tag{4}$$

with t_s = tax on transfer of property, or sales tax on capital goods where applicable, δ = economic depreciation rate, h = capital risk, k = investment tax credit rate, A = present tax value of the accumulated capital cost allowance = $U\alpha\,(1 + r^f + \alpha)/(\alpha + r^f + \pi)$, α = tax depreciation rate, ι = capital tax rate, tg = gross receipts tax rate, and tp = property tax rate.

b) Inventory

For inventory:

$$r^G = (1 + t_s)(r^f + h + U\pi\xi)/[(1 - U)(1 - tg)] + \iota - h \tag{5}$$

with t_s = sales tax on inventory where it is applicable, and $\xi = 1$ for FIFO accounting method and 0 for LIFO indicating that FIFO will result in a taxation on inflated profits when inflation rate (π) is greater than zero.

c) Land

For land:

$$r^G = (1 + t_s)(r^f + h)[1 + \iota\,(1 - U)/(r^f + \pi)]/[(1 - U)(1 - tg)] + tp/(1 - tg) - h \tag{6}$$

with t_s = tax on transfer of property, particularly land.

v) ***Aggregation***

The METR on capital, t_c, is the proportional difference between the weighted average of gross-of-tax rates of return and the net-of-tax rate of return on all types of assets. As the net-of-tax rate of return is the same across asset types within a given country, t_c can be calculated as:

$$t_c = \textstyle\sum_i w_i\,[(r^G_i - r^N_i)/r^N_i] = (\sum_i r^G_i\,w_i - r^N)/r^N \tag{7}$$

where i denotes the asset type (*i.e.*, buildings, machinery, inventories, or land in our case), w_i denotes the weight of asset type i.

The above statements illustrate the general format of the formulae used to calculate the METR on capital. Due to the variance among different jurisdictions, some variables in the formulas can be zero for some jurisdictions. For example, in the case examined here, sales taxes have little impact on capital goods and taxes on the transfer of land are ignored, thus $t_s = 0$ in the above formulae.

2. The Marginal Effective Tax Rate on Labour

It is often assumed that only payroll taxes paid by employers are effective labour taxes borne by employers. Another common assumption is that the marginal unit of labour input is calculated based on an average worker. Therefore, the METR on labour is the total payroll taxes paid by employers on average labour costs. This estimate can be arrived at by two approaches: by dividing the total payroll taxes paid by employers on total payroll on an annual base, or by converting the statutory payroll tax rates to an effective average tax rate on average earnings. For example, if the threshold for a 5% payroll tax is 100 and the average earnings is 160, then the METR is 3.125% (= 5% * 100/160). Obviously, the former method is more accurate *ex post* while the later is a reliable proxy for predictions according to statutory changes.

3. The Marginal Effective Tax Rate on Material

With the assumption that material inputs are always products of the up-stream production stage, the METR on materials, t_m, can be estimated as:

$$t_m = (1 + METR_u * B)(1 + t_s) - 1 \qquad (8)$$

with $METR_u$ = METR on production costs of the up-stream stage, B = tax-shifting factor, and t_s = commodity taxes. Obviously, when commodity taxes are exempted for material inputs (as in the case of our study), the formula becomes $t_m = METR_u * B$. Formulas for calculating the METR on production cost and the tax shifting factor are introduced later in this annex.

4. Estimating Support to Energy

As mentioned in the text above, if the METR on the cost of generating power is available, the METR (including any marginal support) on energy inputs can be estimated using the same formula as is used to calculate the METR on materials. However, due to the government ownership – and the related non-taxability – of many electricity suppliers in our case study, it is not possible to estimate the METR on the cost of generating power accurately. Furthermore, the non-taxability of government-owned electricity generators as well as their access to lower financing costs than available to investor-owned electricity generators (IOEs) due to government intermediation in financial markets creates the potential for below-market sales of energy to GOE customers.

There are several methods available to estimate a benchmark price by which to determine the level of hidden support. Besides comparing the GOE price directly with its IOE counterpart, a more sophisticated method is to estimate the "missing costs" of GOE production by taking into account the capital risk on IOE operations which is applicable, but not chargeable, to GOEs. That is, the missing cost of production for GOEs is mainly related to its missing cost of capital due to the fact that GOEs are not required to pay premiums on their capital risks. By ignoring the non-taxability, the "missing cost" can be estimated using the following steps:

i) Assessment of the IOE's *capital risk*

As is well known, capital risk can be measured by the value of beta (β). Furthermore, the capital market values risk on equity and debt differently, although the two risks for a given firm/industry are related to each other through its debt to assets ratio. Assume that β^e = levered beta for equity, β^d = beta for debt, and b = tax-corrected debt to assets ratio,[8] the capital risk of an average IOE can be estimated by:

$$\beta = (1 - b)\,\beta^e + \beta^d \qquad (9)$$

ii) *Estimate risk-premium on equity of* GOE

As GOE's risk on debt can be valued as the same as that for IOEs, the missing cost of capital for GOEs arises mainly from the uncharged risk-premium on its equity. Furthermore, as GOEs in general incur a much higher debt to assets ratio, its equity risk could be much higher than that of an IOE if it were valued by the market. Assume that b' = GOE's debt to assets ratio, then GOE's equity risk, $\beta^{e\prime}$, can be estimated by:

$$\beta^{e\prime} = (\beta - b' \beta^{d})/(1 - b') \qquad (10)$$

Then the risk-premium required on GOE's equity, R', is the product of $\beta^{e\prime}$ and the market risk-premium.

iii) *Estimate the missing cost of production*

The missing cost of capital, C', can be estimated as C' = R' * total value of equity. C' is also the missing cost of production. Dividing C' by total units of product(s) results in a proxy of the hidden costs or support per unit.

5. The Marginal Effective Tax Rate on Cost of Production

By using the augmented Cobb-Douglas production function, the METR on cost of production, T, can be estimated as:

$$T = \Pi\ (1 + t^{i})^{\alpha i} - 1 \qquad (11)$$

with t^{i} = METR on each input for the production, α_i = share of each input in a given production cost, and i indicating capital, labour, raw material, and energy.

6. The Tax-shifting Factor

As explained in the text, the tax shifting forward factor, B, is crucial in estimating the marginal effective tax rate on a multi-stage production process. In a closed economy, the tax-shifting factor is determined only by the domestic market conditions (*i.e.*, demand and supply elasticity). The formula for such an estimate is:

$$B = E^{s}/(E^{s} - E^{d}) \qquad (12)$$

In an open-economy, the estimate is complicated by the degree of openness and the related cross-boarder elasticity. That is,

$$B = E^{s}/(E^{s} - xE^{d} - (1 - x)\ E^{f}) \qquad (13)$$

with x = the ratio of domestic demand to domestic supply as an indicator of the degree of openness, E^{f} is the price elasticity of demand for exports when $x < 1$ and price elasticity of supply of imports when $x > 1$.

Notes

1. The statistics on a range of different metal products which can be produced from recycled or primary materials were averaged to represent a standardised "metal" for the study.
2. This assumption is certainly arguable in that the used material in the recycling process is generated from the manufactured material. However, for simplicity we assume the used material is generated from the abandoned garbage that has no value left from the previous consumption stage.
3. Refer to Mintz (1993) and Koh, Berg and Kenny (1996).
4. Refer to the annex for the full methodology.
5. As is well known, the value of a tax-shifting factor is determined by the relevant market conditions. Our literature research showed that, for both copper and iron, the long-run supply elasticity for the scrap material is infinite, while the long-run supply elasticity for the primary material is 0.3. Unfortunately, the discussion on demand elasticity is beyond our subject and there is no clear-cut estimate available. Therefore, the values of tax-shifting factor used in our simulation are artificial estimates and for illustration purposes only.
6. Boadway, Bruce and Mintz (1984, 1987).
7. Chen and Mintz (1993).
8. That is, $b = (1 - u)\, D/[E + D\, (1 - u)]$, with D = total debts, E = total equity, u = corporate income tax (CIT) rate. By including the CIT rate, the formula adjusts the original debt to assets ratio (= D/(E + D) by the deductibility of interest income for CIT purpose. This adjustment recognizes the partial-risk-sharing feature of the CIT system.

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Environmental Impacts of Agricultural Support: Cereal Irrigation in France

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1. INTRODUCTION

Abundant international literature, including many OECD studies, has revealed the factors causing intensification of agriculture, in particular via price and input support, and its adverse implications for the environment. These are now well established and need not be reiterated here. Solutions to the problem, however, are more controversial owing to the institutional management of agriculture but also to more technical factors relating to the nature of the pollution caused by intensification. The fact that it is non-point, multi-agent pollution makes it hard to identify the sources or assign clear-cut liabilities. The irregular pattern of environmental impacts and the randomness involved compound the problem and complicate the use of efficient internalisation systems. Nevertheless, the general thrust is still towards reducing the more serious distortions stemming from inappropriate support schemes. It has also been demonstrated that some of the points made about the ineffectiveness of taxing polluting inputs for environmental purposes, in particular fertilizers, require qualification when other inputs with a more distant time-horizon are taken into account (Vermersch *et al.*, 1993).

Looking beyond the effects of input taxation, a broader approach is needed to see how the production mix as a whole is affected by variations at the margin for several production factors. This entails reasoning in terms of the Marginal Effective Tax Rate (METR) with a view to greater social efficiency (OECD, 1998). It means identifying the best incentives, namely the taxation of – or support removal from – environmentally adverse factors and, where appropriate, subsidisation of environmentally friendly factors. In this respect, irrigated and non-irrigated cereal systems are a very good case in point, given existing distortions and impacts stemming from intensification.

The first section of this paper reports on the status of irrigation in France, describing the situation in detail and discussing the factors behind its recent development, including the Common Agricultural Policy (CAP) and direct incentives.

The second section presents an optimal yield model involving the above factors, with microeconomic modelling showing how each factor plays a part in producer decision-making. The short-, medium- and long-run analyses set out in detail the implications of support schemes, particularly for land quality. The theoretical results are illustrated by a number of empirical observations.

2. IRRIGATION: CURRENT SITUATION AND REASONS FOR ITS DEVELOPMENT

Irrigation has played a key role in the intensification of the agricultural production process, thanks to direct and indirect support. The first section of this chapter takes stock of the situation, in particular with the help of a recent general census of French agriculture and the latest structural survey conducted in 1995. These show a steep rise in irrigated acreage. The second section describes the direct support granted for access to water resources and the indirect support in the form of low with drawal charges, demonstrating how profitable irrigation can be for private individuals. The third section focuses on the impact of CAP (Common Agricultural Policy) reform, which has introduced a differential into compensatory payments depending on whether crops are irrigated or not. The fourth section sets out a number of empirical findings on the behavioural responses to the subsidies.

2.1. Current situation

Until the 1992 reform of the Common Agricultural Policy, generally high production prices combined with a guaranteed market generated strong growth in supply. Given the constraints of land availability, such growth was only possible via intensification. Here agro-chemicals (fertilizers and pesticides) played a vital role. But beyond a certain point it was realised that the limiting factor for increasing agricultural yields was water, *i.e.*, either too much or too little moisture in the soil. Hence the development of programmes to encourage drainage or, conversely, irrigation. Given the scale and importance of irrigation in agricultural support, it is the focus of this paper.

Data prior to the 1970 census does not give a clear picture of the situation, but subsequent figures show how irrigation has taken on increasing importance in French agriculture (see Table 1).

Table 1. **Trends in farmland equipped for irrigation from 1970 to 1995**

	1970	1975	1979	1988	1990	1995
% of usable acreage equipped	1.8	2.2	4.5	6.3	7.4	8.9
% of farms equipped	8.4	10.2	11.8	13.4	15.0	16.8

Source: RGA (general agricultural census) for 1970, 1979 and 1988; EPEXA survey for 1975; Structure survey for 1990 and 1995.

Table 1 shows how the share of farms equipped for irrigation doubled between 1970 and 1995, while total irrigated acreage multiplied fivefold over the same period.

Prior to 1970, the Ministry of Agriculture's hydraulics department published figures for acreage equipped for irrigation, but only via shared schemes. This stems directly from the establishment of *Sociétés d'Aménagement Régional* (regional development companies) in the 1950s to develop large-scale projects in areas with the greatest problems of access to water resources. Between 1961 and 1969, these projects accounted for 56 per cent of all acreage equipped for irrigation, with the largest share going to the *Compagnie Nationale d'Aménagement du Bas-Rhône Languedoc* in the south of France. In the late 1960s, irrigation was developed mainly in the Mediterranean areas (Languedoc-Roussillon, Provence-Alpes-Côte d'Azur and Corsica). This was understandable, as these areas require at least 100 mm of water in more than 9 years out of 10. Next came Aquitaine, Midi-Pyrénées, the Centre, Poitou-Charentes and the Rhône Valley, where the rate is a little lower, at 7-9 years out of 10. These are precisely the areas that have recorded the steepest rise in irrigated acreage recently. In Poitou-Charentes, for instance, the figure was multiplied elevenfold between 1970 and 1990.

This rise in irrigated acreage is connected with changes in crop type. Traditionally, irrigation was used for market gardening and horticulture, as well as orchards. In 1975, as Table 2 shows, this group of crops accounted for 41 per cent of irrigated land. By 1995 the figure had fallen to 27 per cent. Maize, at 43 per cent, now heads the list of irrigated crops (compared with under 35 per cent in 1975 and probably far less a decade earlier). Other successful irrigated crops include soyabean and sunflower, accounting for a combined figure of 7 per cent in 1995 compared with 0.5 per cent two decades earlier.

Irrigators have either individual or shared access to water resources. Individual access means that the farmer has sole access to water. Half of all farms equipped for irrigation fall into this category. Less than 40 per cent (39 per cent in 1995) belong to shared systems, some of which have "public" status since they are managed by

Table 2. **Irrigated land in 1975 and 1995 by type of crop (% of total irrigated land)**

	1975	1995
Maize	34.6	43
Fodder	8.7	9
Vegetables	5.9	8.8
Orchards	13.0	8.6
Soyabean	–	5
Legumes	–	5.2
Cereals (not maize)	5.5	4.4
Industrial beet	2.4	3.1
Potatoes	2	3
Permanent grassland	10.8	3
Vines	6.7	1.7
Sunflower	–	1.5
Other	10.4	3.8
Total	**100**	**100**

Source: Irrigation in Agricultural Production 1975; Agricultural Statistics, April 1979, No. 171; Structure Survey for 1995; Rural Notebooks Nos. 7-8, October 1996.

the *Sociétés d'Aménagement Régional*, whereas others have been set up by a farm union to share the resource. The 11 per cent gap in the figures stems from the fact that some farms practise both individual and shared irrigation. Table 3, which lists the irrigated acreage in each category, shows that individual access is ahead and on the increase. A comparison of acreage and the number of farmers shows that it is the larger farms that practise individual irrigation only.

In fact the breakdown between shared and individual systems follows a regional pattern, which in turn relates to weather conditions and problems of access to water resources that have required specific government policies. South-east France, for instance, is characterised by a high rate of shared irrigation systems, accounting for 70 to 80 per cent of the acreage equipped for irrigation in 1988.

Table 3. **Share of irrigated land, by type of access to water resources, in 1975 and 1988**

	1975	1988
Individual only	58.7%	61.7%
Joint only	29.6%	21.0%
Combined	11.7%	17.3%

Source: EPEXA 1975 and RGA 1988.

Conversely, in the four main irrigated regions in the West and Centre (Aquitaine, Midi-Pyrénées, Poitou-Charentes and the Centre), only 16-36 per cent of the acreage is equipped for shared irrigation.

This contrasting pattern is important in that it reflects three very distinct situations:

1. The Mediterranean areas have highly subsidised shared irrigation schemes, but offer little support for fruit and vegetable crops.
2. The Centre and Poitou-Charentes regions with mainly individual irrigation schemes, where investment costs are mainly borne by the farmer but crops are subsidised.
3. The South-West (Aquitaine and particularly Midi-Pyrénées) with combined (individual/shared) access to water and relatively well subsidised crops.

2.2. Reasons behind the development of irrigation

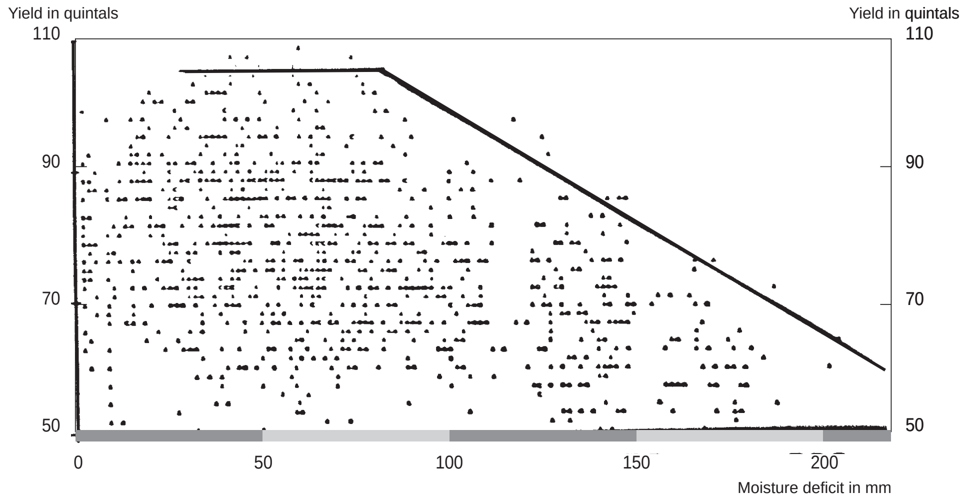
Irrigation is obviously used to increase the private profitability of agriculture for the farm owners.

From the findings of agricultural surveys covering over 1 000 parcels over a 5-year period in the Eure-et-Loire *département* it is possible to measure the private benefits from irrigating wheat from 1 April to 10 July. The surveys can be used to produce an overall curve showing maximum yields as a function of the soil moisture deficit between April and July, with no restrictions from other inputs (Darbin *et al.*, 1990). Figure 1 shows that a water input reducing the moisture deficit from 200 mm to 100 mm (*i.e.*, a reduction of 100 mm) increases the yield by 35 quintals per hectare. But when the deficit is reduced from 100 mm to zero mm the yield is increased by only 10 quintals per hectare.

Data collected by the *Réseau d'Information Comptable Agricole* (RICA) or Farm Accounting Data Network on arable crop systems showed that maize yields rose by 33.3 quintals per hectare (q/ha) in the Centre region between 1987 and 1995. In Poitou-Charentes the difference was 24.5 q/ha. A short calculation shows that at current prices for commodities and inputs (including water), it is worthwhile irrigating maize as soon as the additional yield exceeds 22 q/ha. As the break-even point depends on numerous factors such as soil/climate conditions, investment in equipment, and technical expertise, the literature sets it at between 16 and 30 q/ha (Teissier, 1996).

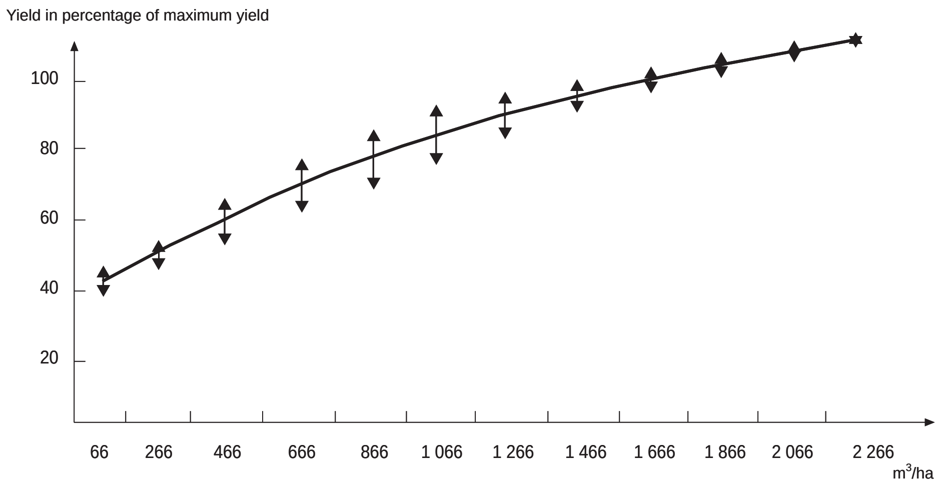
Another common argument in favour of irrigation is that it counteracts risk; the droughts in 1976, 1985/86 in the south-west, 1988/91 and the beginning of 1997 have made French farmers highly aware of the risks linked to weather conditions. Rio's findings (Rio, 1994) obtained from simulating maize yields as a function of water input, show that yield variability, in terms of standard deviation, declines as irrigation increases (see Figure 2).

Figure 1. **Maximum wheat yield in Eure-et-Loir and soil moisture deficit between 1 April and 1 July**



Source: Darbin *et al.,* 1990.

Figure 2. **Maize yield as a function of irrigation, and yield variability**



Source: RIO, 1994. Arrows indicate standard deviation in yields.

Irrigation may be viewed as a barrier to entry on some markets, such as the contract growing of seed or vegetables. This stems from the need to be able to guarantee both output and also quality, in terms of size for instance, regardless of weather conditions. In Picardy, for example, with its large vegetable-canning factories, irrigation is practised to ensure output levels and quality.

However, the widespread use of irrigation is also because water is so readily available. This is illustrated by a comparison of the access costs per hectare of irrigated land for an individual groundwater-pumping system and for a shared irrigation system using an overflowing river in the Midi-Pyrénées (Martin, Annex 3, 1996). It is assumed *a priori* that the river is replenished from a low-water regulation reservoir, with investment costs of FF 8 per cubic metre. The cost of supplying water at the outlet (*i.e.*, the cost of creating a shared system) is calculated to be FF 30 000 per hectare. For an individual scheme in the Beauce area, a 40-metre bore-hole with an hourly flow of 100 cubic metres to irrigate 50 ha costs the farmer FF 270 000 with the pumping plant and underground delivery, or FF 5 400 per ha.

On the basis of a 25-year depreciation period, the access costs amount to FF 2 920 per ha for a shared system compared with FF 500 per ha for the pumping option. In fact, these are generally not the costs actually incurred by farmers, particularly when it comes to surface-water schemes which have received all kinds of support (from the government, the regions and the *départements*). Europe has also given incentives for agricultural hydraulics, provided that the projects are beneficial to land-use planning policy. The Integrated Mediterranean Programmes have leveraged considerable funding in this area. The building of low-water regulating dams, for instance, can receive 100 per cent subsidies. For shared irrigation schemes, work to lay on water can be subsidised up to 70 per cent (65 per cent in the Midi-Pyrénées region for systems financed between 1990 and 1992).

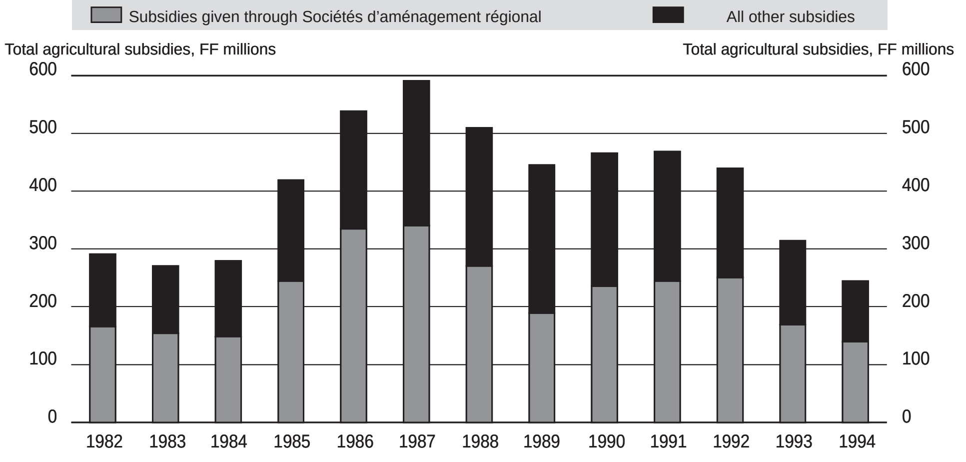
Figure 3 shows the trends in government support for irrigation in constant French Francs since 1982, using three-year averages to smooth out the series, and distinguishes support going directly to irrigators from support that is paid via the *Sociétés d'Aménagement Régional*. It shows that these companies channel at least as much support as the others. It also shows the clear decline in support triggered by CAP reform after the peaks in 1986-1988 to cover the drought.

Some *départements* and the water agencies provide support for harnessing water resources as well. The Seine-Normandy and Loire-Brittany agencies subsidise 20 per cent of the costs, except for "intensively used" aquifers.

Overall, the access cost to co-sharers in an irrigation scheme is very similar to the cost of boring for groundwater, *i.e.* FF 600 to 700 per hectare, or FF 0.40 to 0.50 per cubic metre on the basis of 1 500 cubic metres per ha.

The second incentive for irrigation stems from the very low charges that irrigators have to pay to the water agencies. Every year farmers withdraw an estimated 4.9 billion cubic metres (1 billion from aquifers and 3 billion from surface water), yet

Figure 3. **Trends in government support for irrigation from 1982 to 1994**
In FF millions at 1980 prices; three-year averages



Source: Statistique agricole annuelle.

they are only charged for 1.3 billion cubic metres (A*nnuaire* S*tatistique de la* F*rance*, 1997). This is because livestock farmers can use run-off water from hillside lakes free of charge. And irrigators who are not in a shared scheme will be charged on the basis of what they declare. For bore-holes, an authorisation is required if the hourly flow exceeds 80 cubic metres; notification is sufficient for an hourly flow of between 8 and 80 cubic metres, and below 8 cubic metres per hour farmers can do what they like. In theory, water meters have been compulsory since 1 January 1997. In the North-Picardy region 90 per cent of farms have meters, while in Loire-Brittany the figure is 50 per cent (with a very low percentage in the Centre) and in the south-west only 30 per cent. On the other hand, in half of the south-east region the rate is a full 100 per cent.

For those who pay for groundwater withdrawals, water costs from FF 0.02 to 0.10 per cubic metre, except in two parts of the Artois-Picardy region where it costs FF 0.16 and 0.28, respectively (Martin, Annex 3, 1996). When there is no meter, the cost is usually based on irrigated acreage, with a flat rate per hectare and no distinction between ground and surface water. The flat-rate charge relates to withdrawals, with actual prices varying from one water agency to another. A simulation based on arable crops gives FF 30 per ha in Adour-Garonne, FF 63-158 in Artois-Picardy, FF 53-204 in Loire-Brittany (FF 25-98 if meters are used), FF 48-280 in Rhône-Mediterranean-Corsica, and FF 77 in Seine-Normandy. Thus, the amount actually paid by farmners for irrigation water is substantially lower than the costs of the withdrawals.

2.3. CAP reform and reference yields

Below is a brief summary of the main changes that CAP reform has brought about for cereals, oilseed and high-protein crops:

– set-aside has been reduced to 5 per cent of acreage, offset by a diversion payment;

– cuts in guaranteed prices (market price support), bringing them closer in line to world prices, and in export refunds. In exchange, farmers receive premia per hectare commensurate with a reference yield that is based partly on the average yield for the *département* (2/3) and partly on national yield (1/3).

To calculate the reference yield, France has introduced a special system that distinguishes between irrigated and non-irrigated crops. The calculation ensures that, in a single *département*, the total amount of premia paid out equals the figure based on the average yield, regardless of whether irrigation has been used. This amounts to transferring support away from non-irrigators, and to irrigators. However, an adjustment is made by giving national yield a one-third weighting. In fact, this method was devised to let irrigators enjoy established benefits, while also sparing them a system that would prevent them from writing off their irrigation investment costs (an estimated FF 600 per ha for mobile equipment).

Conversely, in each of the *départements* opting for the dual reference yield, a ceiling was placed on irrigable land based on the average irrigated acreage over the period 1989, 1990 and 1991. Farmers were allowed to add to this the acreage rendered irrigable "by investments made by 1 August 1992 at the latest". But this lacked clarity too, as the ceiling was based on the farmer's own figures, and there is of course a big difference between the acreage equipped for irrigation and the amount of land actually irrigated (ranging from 1 to 2.2 in the Centre, for instance).

If the irrigated acreage exceeds the departmental ceiling, there will be a proportional decrease in individual support per hectare of irrigated land because the overall funds available remain unchanged. In theory, the following year an area of land matching the excess acreage must then be set aside. The fact that this is a collective penalty, with little impact on individuals, is bound to encourage "free-riding". It would have been more logical and efficient to impose penalties on individual farmers who exceed the ceiling.

Map 1 shows departmental levels of reference yields (on which premia are paid) for irrigated and non-irrigated crops, for all cereals and for maize alone, although other crops (including soyabean and sunflower) also benefit from the dual

Map 1. **Compulsary allowances for irrigated and non-irrigated cereals by department 1996, in FF per hectare**

Bold type: all cereals Normal type: non-irrigated cereals ▭ Irrigated maize ▭ Non-irrigated maize

system. In some *départements* there is a substantial difference in the reference yields depending on whether the crop is irrigated or not. In Hérault, for instance, the difference is as high as FF 1 990, or FF 1.33 per cubic metre of irrigation, on the basis of 1 500 cubic metres per ha. By and large, in areas where the cost of access to water and the price charged for water is low, these differentiated reference yields make irrigation, and hence intensification, more worthwhile.

An outline of the impact of the CAP reform clarifies the operation of reference yields, using Landes as an example (Table 4). This *département* features very extensive use of irrigation and is a large maize growing areas. In determining prices, the net national price actually received by producers was used.

Table 4. **Calculation of the impact of the CAP reform in the Landes region, based on reference yields of 70.4 quintals/ha for non-irrigated maize and 92.9 quintals/ha for irrigated maize, and assumption that 15% of land is set-aside**

Gross Product/ha in 1992 (price per quintal = FF 98)			
98 FF/q × 90 q =	FF 8 820		
Gross product/ha in 1994 (price per quintal = FF 75.8)			
Non-irrigated		Irrigated	
Income from agricultural sales from cultivating 85% of land (75.8 × 70.4 × 0.85)	4 536	75.8 × 92.9 × 0.85 =	5 985
Compulsary allowance	1 945		2 567
Set-aside premium for 15% of land (2 467 × 0.15)	370		370
Total	**6 851**		**8 992**
Gross product/ha in 1995 (price per quintal = FF 85.93)			
Non-irrigated		Irrigated	
Income from agricultural sales from cultivating 85% of land (85.93 × 70.4 × 0.85)	5 142	85.93 × 92.9 × 0.85 =	6 785
Compulsary allowance[1]	2 529		3 337
Set-aside premium for 15% of land (3 390 × 0.15)	508		508
Total	**8 179**		**10 630**

1. The compulsary allowances for the year 1996 are shown in Map 1, and are 2 493 and 3 290 for non-irrigated and irrigated maize in Landes respectively.

As can be seen from this example, irrigated crops are more profitable than non-irrigated crops because of the support offered under the Common Agricultural Policy. The same result is obtained if the calculation is based on the average for the *département* except that the differential between irrigated and non-irrigated crops is obviously larger (FF 2 451/ha in 1995).

It should be noted that this differential of FF 2 451 is higher than the additional cost of irrigation including additional inputs and the cost of water (the differential between irrigated crops in SW RICA (accounting network) and non-irrigated crops is less than FF 2 000).

Finally, this system of reference yields which distinguishs between irrigated and non-irrigated crops is also applied in Spain for the "comarcas" and in Portugal where there are 6 irrigated regions and 6 non-irrigated regions. Greece makes a distinction between irrigated maincrops and non-irrigated maincrops.

2.4. A few empirical results

A preliminary approach was conducted on the basis of a set of cereal farms monitored by the Réseau d'Information Comptable Agricole (RICA) from 1987 to 1995. From the three most representative regions in this accounting network (Centre, Poitou-Charentes, Midi-Pyrénées), two sub-sets were selected, one practising irrigation and the other not.

Sample sizes vary across regions, which is bound to have an impact on the results given that the aim is to be strictly representative. But, as the main objective is to identify the leading structural components and their behavioural implications, significant data will suffice and is available here. Furthermore, the panels are not standardised because of annual renewal among the basic farm units in the RICA network. For the nine years in question, we have combined some basic data in Table 5 and produced mean values for each of them, separating the irrigated from the non-irrigated production systems in each region.

Table 5. **Average characteristics of farms in the study for the period 1987-1995**

	Centre		Poitou-Charentes		Midi-Pyrénées	
	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated
Average number of farms	131	29	15	16	15	36
Average farmland usable (ha)	102	129	70	94	69	84
Average wheat yield (q/ha)	61.8	70.5	54.8	55.4	50.3	49.3
Average maize yield (q/ha)	65.5	98.2	67.5	90.9	46.8	79.6

Table 5 clearly shows how small the sample is, other than for non-irrigated crop systems in the Centre. It also shows that the Centre has farms with approximately 1.5 times more usable farmland than the other two regions in the study. Farms that irrigate are always larger than farms that do not (one-quarter to one-third larger). As we have seen, irrigation pushes up the maize yield by almost 33 q/ha in the Centre and Midi-Pyrénées compared with 23.4 q/ha in Poitou-Charentes. For wheat, the only difference in yield is found in the Centre (8.7 q/ha), the main region with irrigated wheat, and very little at that.

To refine the results, we took each region in turn and compared farms that irrigated with those that did not, comparing characteristics at the beginning of the period (the average for 1987, 1988 and 1989) and at the end (average for 1993, 1994 and 1995). This time-divide helps to illustrate the impact of CAP reform. A detailed analysis of the production combination suggests a number of conclusions:

i) With regard to output per hectare, the higher productivity obtained through irrigation tends to rise over time. This is all the more significant because the productivity of non-irrigated land tends to decrease, except in the Midi-Pyrénées region. Intensification – defined on the basis of productivity – has therefore been encouraged under the new CAP rules on irrigation. However, this statement requires qualification if both factor shares and trends are taken into consideration, as the issue is more complex.

ii) With respect to agro-chemicals (fertilizers and pesticides), the amounts used per hectare differ very little whether the land is irrigated or not, except in the Midi-Pyrénées region where irrigation goes hand in hand with a significantly higher input of fertilizer. On the contrary, over time there is a general decline in doses of agro-chemicals per hectare. The factor shares, on the other hand, show that fewer chemicals are used for every FF 10 000 of crop output when the land is irrigated. In other words, for a comparable output less use is made of polluting inputs.

iii) With regard to intermediate inputs like equipment depreciation and fuel, more are used per hectare when the land is irrigated than when it is not. In terms of factor share, the levels are roughly comparable. These two inputs, which are complementary, indicate the presence of special irrigation equipment. It is worth adding that the factor share of irrigation water, which is relatively low in the Centre and Poitou-Charentes regions, reaches proportions comparable with fuel and other intermediate inputs in the Midi-Pyrénées.

iv) As for labour, the number of hours per hectare and the number of hours required to produce FF 10 000 of output are very similar for irrigated and non-irrigated land. The Centre is characterised by greater labour efficiency, whether irrigation is used or not. Furthermore, that efficiency rises over time in every region, but the rise is steeper for irrigated crops. This suggests economies of scale and a simplified cropping system, hence economies of specialisation.

v) Apart from effects of scale and specialisation, differences between regions can generally be put down to soil and climate conditions. For instance, the very low output for non-irrigated crops in the Midi-Pyrénées is due to the serious drought recorded there at that time of year. In addition, fertility varies noticeably in the Midi-Pyrénées and the Centre and this affects the factor shares for fertilizer use on irrigated land.

In addition to these preliminary conclusions, it should be stressed that the mechanisms introduced by the CAP reform did act as an incentive to further develop irrigation on farms and, at the same time, to increase output per hectare. However, this increase did not generate a commensurate increase in the use of polluting inputs. This can be attributed instead to farmers reducing technical inefficiencies, under the shock of falling prices. This has been confirmed in work by other authors (Piot-Lepetit *et al.*, 1997).

3. MICROECONOMIC MODELLING

To the extent that there is an association between environmental damage, intensification and yield levels, it is important to determine the part played by various forms of direct and indirect support for irrigation along with the other variables. Below is a microeconomic model showing the behaviour of farmers growing cereals (*i.e.*, grains in general). Whereas some crops could never be grown without irrigation, most of the cereals produced in temperate climates can be grown either with or without the use of irrigation. So this provides a textbook case of a continuum of technologies for producing agricultural goods with different levels of harmful effects on the environment.

The behaviour assumed in the model is profit maximisation by the farmers. To integrate modes of adjustment properly, the model must mirror optimisation by the farmer as closely as possible. Profit maximisation is a borderline case, so the assumption will be relaxed when developing the model, allowing for several different adjustment horizons. Finally, we will consider the links between optimal yield, with the reference yield serving as a basis for the direct support introduced in 1992, and the prices charged for water.

3.1. A dual model based on monocropping

This model is applied to cereal monocropping and makes it possible to derive an optimal cereal yield that we shall consider to be the major argument in the damage function. The technology is represented by a restricted cost function corresponding to variable costs (fertilizer, fuel, pesticides, water, etc.) expressed as x and including:

– the level of output y;

– the acreage of farmland in use T;

– a parameter $\theta \in [0,1]$ representing the proportion of farmland in use equipped for irrigation;

– the amount of labour L;

The assumptions included in the model that restricted cost is maximised and the production possibilities set is convex ensure that the cost function is, as it were, an exhaustive measure of the technology. Written here as CR (y, T, θ, L), the function is then combined with a simple Cobb-Douglas functional form:

$$CR\,(y, T, \theta, L) = A y^{\alpha} T^{\beta} \theta^{\gamma} L^{\delta} \qquad (1)$$

with α, β, γ and δ representing the respective elasticities of cost for each argument y, T, θ and L. The scalar A is strictly a function of the other quasi-fixed factors of production such as capital (equipment and premises) and the price vector w_x of the variable factors, the function A (w_x,.) being linearly homogeneous in w_x.

Furthermore CR (y, T, θ, L) results from the following:

$$\begin{aligned} &\underset{x}{Min}\; w'_x \cdot x \\ &y = f\,(x, T, \theta, L) \end{aligned} \qquad (2)$$

with f denoting the production function based on the classic assumptions of regularity and free-availability of all production possibility sets. Using the same assumptions, CR (y, T, θ, L) increases in y and decreases in relation to T, θ and L; within the framework of our model, this gives the following constraints:

$$\alpha \geq 0,\ \beta \leq 0,\ \gamma \leq 0,\ \theta \leq 0 \qquad (3)$$

Assuming that f represents all or part of the frontier of a convex production set, then CR (y, T, θ, L) is convex in y; hence:

$$\alpha > 1 \qquad (4)$$

assuming that CR (y, T, θ, L) is twice differentiable. This again gives $\alpha > 1$ if we assume decreasing returns to scale on the expansion path; and the condition can be described as follows:

$$\left[\frac{\partial \log CT}{\partial \log y}\right]^{-1} < 1 \qquad (5)$$

The latter corresponds to short-run economies of scale. That being so, and providing we know CR (y, T, θ, L), it is possible to determine a measurement for long-run economies of scale (Vermersch, 1990). This is done by defining the total cost function CT (y, w_T, w_θ, w_L) resulting from the following:

$$\underset{T,\,\theta,\,L}{Min}\, CR\,(y, T, \theta, L) + w_T T + w_\theta \theta T + w_L L \qquad (6)$$

w_T and w_L denote the cost of land per hectare and the remuneration of a unit of labour, respectively, while w_θ is the annual cost to the farmer of irrigation equipment depreciation per hectare of irrigated land. A situation involving diminishing economies of scale is therefore:

$$\mathrm{ECH}^{\mathrm{LT}} = \left[\frac{\partial \log \mathrm{CT}}{\partial \log y}\right]^{-1} < 1 \qquad (7)$$

Combined with the fact that $\theta \in [0,1]$ and, under the assumption of generally decreasing returns to scale,[1] the preceding inequality leads to new constraints on the parameters given for two factors in Vermersch *et al.* (1994).

Finally, the Cobb-Douglas type functional form (1) used for the restricted cost function offers the advantage of directly giving a partially primal expression of the technology:

$$y = \left(\frac{\mathrm{CR}}{\mathrm{A}}\right)^{\frac{1}{\alpha}} \mathrm{T}^{\frac{-\beta}{\alpha}} \theta^{\frac{-\gamma}{\alpha}} \mathrm{L}^{\frac{-\delta}{\alpha}} \qquad (8)$$

that we will use in the econometric example.

3.2. Several time horizons

The model must take into account the quasi-fixed nature of some factors such as total acreage, the proportion of irrigated acreage and the amount of labour. This is because under long-term optimisation, acreage can be adjusted like the other variables, including fertilizer, seed and pesticides. We can also define an intermediate (medium-term) time horizon inasmuch as the proportion of irrigated acreage can be optimally adjusted (by purchasing new irrigation equipment) without any change in the total quantity of acreage T. It may be easier to buy a new hose drum, for instance, than to buy – or rent – another hectare of land. There are two reasons for this: investment in equipment is relatively cheap and an imperfect, rigid land market ensures few land transactions take place.

By and large, the various time horizons examined correspond to the actual scope for adjustment depending on factors of production. In all the cases studied below, therefore, we shall consider producers to be technically and allocatively efficient. This assumption may have to be qualified with a non-parametric approach based on situations that are technically inefficient (Piot-Lepetit *et al.*, 1997).

When land, irrigated land and labour are fixed

Here, the producer is assumed to be maximising his restricted profit:

$$\underset{y}{\mathrm{Max}}\; py - \mathrm{A}y^{\alpha}\mathrm{T}^{\beta}\theta^{\gamma}\mathrm{L}^{\delta} \qquad (9)$$

with p being the commodity price. The solution gives us the optimal cereal supply:

$$y = \left[\frac{p}{\mathrm{A}\alpha\mathrm{T}^{\beta}\theta^{\gamma}\mathrm{L}^{\delta}}\right]^{\frac{1}{\alpha-1}} \qquad (9a)$$

or the short-run yield:

$$r_{T,\,\theta,\,L} = \left[\frac{p}{A\alpha T^{\beta+\alpha-1}\theta^{\gamma}L^{\delta}}\right]^{\frac{1}{\alpha-1}} \qquad (9b)$$

This equation shows the sensitivity of short-term yields to commodity prices. This is empirically confirmed by examining the trend in net crop prices received by maize producers with yields. Table 6 sets out both variables using yield figures from Landes, which is the *département* with the largest maize-growing surface area (approximately 140 000 ha, or twice the area in the second ranking *département*, the Gers). The Landes also shows a large share of irrigated area (over 40 per cent of usable surface area).

Table 6. **Unit price of maize paid to farmers (national price per quintal) and yield in quintals per ha (in the Landes region)**

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Price	110.37	102.20	99.40	116.60	102.40	98.00	69.40	75.80	85.93	76.46
Yield	87	84	85	73	91	90	91	86	94	103
Surface area (1 000 ha)	143	154	154	147	148	147	134	128	126	135

Table 6 shows that yields were generally rising from 1987 to 1993, when the CAP reform was truly under way, other than for 1990 when weather conditions were particularly unfavourable. The fairly marked drop in unit price in 1993 also resulted in lower yields in 1994, taking into account the lead time between planting and harvesting.

Yields began to rise again in the last few years, which does not really fit equation (9*b*), but several explanations are available, including the further progress that has been made in breeding seed varieties and the current restructuring of farms to create economies of scale. Furthermore, the model envisaged here *de facto* considers producers efficient from a technical standpoint and also in terms of allocation. In actual fact, reducing individual technical inefficiencies did increase cereal yields. Boutitie and Vermersch (1993) measured the technical efficiency of cereal farms in several regions of France and concluded that there was a potential increase in yields of 6.4 per cent in Aquitaine, 11.4 per cent in the Centre and 12.3 per cent in Ile-de-France. These inefficiencies have been partly complemented by, among other things, farm restructuring. Finally, the analysis of medium-term adjustments that occurred following the fall in cereal prices also explains the smaller reduction in yields. This aspect will now be discussed using the microeconomic model.

When land and labour are fixed

Now we will look at an intermediate situation where, for a fixed amount of labour and land, the share θ of land that is irrigated may be adjusted:

$$\underset{y,\,\theta}{Max}\; py - Ay^{\alpha}T^{\beta}\theta^{\gamma}L^{\delta} - w_{\theta}\theta T \tag{10}$$

From this, the following first order conditions are necessary:

$$\begin{aligned} p &= A\alpha y^{\alpha-1}T^{\beta}\theta^{\gamma}L^{\delta} \\ w_{\theta}T &= -Ay^{\alpha}T^{\beta}\gamma\theta^{\gamma-1}L^{\delta} \end{aligned} \tag{10a}$$

This gives a direct expression of yield y/T as a function of the optimal value for irrigated land θ:

$$r_{T,\,L} = -\frac{\alpha\theta w_{\theta}}{\gamma p} \tag{10b}$$

Or:

$$r_{T,\,L} = -\left[\frac{1}{A}\left(\frac{p}{\alpha}\right)^{1-\gamma}T^{1-\alpha-\beta}\left(\frac{w_{\theta}}{\gamma}\right)^{\gamma}L^{-\delta}\right]^{\frac{1}{\alpha+\gamma-1}} \tag{10c}$$

Optimal adjustment of acreage

The previous equation is considerably simpler when acreage can be adjusted to its optimal level; cereal yield is then expressed as the ratio of cereal price to acreage. Let us assume an optimal adjustment of y and of T, then we have:

$$\underset{y,\,T}{Max}\; py - Ay^{\alpha}T^{\beta}\theta^{\gamma}L^{\delta} - w_{T}T - w_{\theta}\theta T \tag{11}$$

with the necessary first order conditions as follows:

$$\begin{aligned} p &= A\alpha y^{\alpha-1}T^{\beta}\theta^{\gamma}L^{\delta} \\ w_{\theta}\theta + w_{T} &= -Ay^{\alpha}\beta T^{\beta-1}\theta^{\gamma}L^{\delta} \end{aligned} \tag{11a}$$

The ratio of the two expressions gives the yield as:

$$r_{\theta,\,L} = -\frac{(w_{T} + w_{\theta}\theta)}{p}\frac{\alpha}{\beta} \tag{11b}$$

If we also assume an optimal adjustment of the proportion of irrigated land and labour, then:

$$r = -\frac{w_{T}}{p}\frac{\alpha}{\beta-\gamma} \tag{11c}$$

In the long run, the cereal yield will depend only on the ratio of cereal price to acreage inasmuch as it is assumed, under the Cobb-Douglas functional form, that elasticities of substitution are constant in relation to other quasi-fixed factors of production.

This example of an optimal adjustment of land also makes it possible to formalize the medium-run impact on cereal yields of the direct support introduced by the 1992 reform of the Common Agricultural Policy. Designed to offset almost fully the decrease (Δp) in grain prices, this support is indexed on a regional,[2] differentiated reference yield depending on whether the crop is irrigated or not. The reference yields are given as r_s, r_i for non-irrigated and irrigated land respectively, and the producer's programme is then:

$$\underset{y,\,T}{Max}\; py - Ay^{\alpha}T^{\beta}\theta^{\gamma}L^{\delta} - w_T T - w_{\theta}\theta T + \Delta p[r_i\theta T + r_s(1-\theta)T] \qquad (12)$$

Or:

$$\underset{y,\,T}{Max}\; py - Ay^{\alpha}T^{\beta}\theta^{\gamma}L^{\delta} - [w_T + w_{\theta}\theta - \Delta p[r_i\theta + r_s(1-\theta)]]^{T} \qquad (12a)$$

It is as if direct support $[\Delta p[r_i\theta + r_s(1-\theta)]]$ pushes down the real cost of land and hence the cereal yield [*cf.* expression (11*b*)]. In the medium run, however, the downward pressure of direct support on land prices may be partly cancelled out by the capitalisation of the support, in the form of rent, into the price of land, which will foster further growth in yield. The recent trend in French land prices shows that the capture of direct support via land transactions is well under way. 1992, for instance, marked a break in French land market trends, which had been declining since 1979: while the decline in land prices has continued (down 11%), there has now been a rise in gross farm income per hectare (up 7%). As early as 1993, the price of arable land began to rise in some regions, such as Champagne-Crayeuse. The recovery grew stronger in 1994 in grain-growing *départements* like Aube (up 4.6%) and Marne (up 4.8%). In 1995, for the first time since 1979, there was a rise of 0.4% across the country as a whole (with arable land up 0.4% and natural grassland up 0.3%). This increase may become even steeper in the future since French prices were still, in 1994, among the lowest in the European Union. Yet the decline continues in the *départements* where lower reference yields are used to calculate direct support.

3.3. Shadow prices for land and a correlative trend in grain yields

When the factors of production are fixed, the analytical expressions obtained for agricultural yield [(9*b*) and (10*c*)] are relatively complex. They can be nicely simplified using the notion of a shadow price. Going back to equation (9), we can define the restricted profit function:

$$\Pi R(p, A, T, \theta, L) = \underset{y}{Max}\; py - Ay^{\alpha}T^{\beta}\theta^{\gamma}L^{\delta} \qquad (13)$$

Assuming that this function is twice differentiable from its main arguments, we can define for instance:

$$\bar{w}_T = \left.\frac{\partial \Pi R}{\partial T}\right|_{\theta,\,L} \qquad (14)$$

Where $\bar{w}_T$ is the shadow price of land and represents the marginal increase in restricted profit following a marginal increase in T. Using (9) and (9*a*), we obtain:

$$\bar{w}_T = -\frac{\beta}{\alpha}\left[\frac{p^{\alpha}}{A\alpha T^{\alpha+\beta-1}\theta^{\gamma}L^{\delta}}\right]^{\frac{1}{\alpha-1}} \qquad (15)$$

We can now express the corresponding yield [equation (9*b*)] as a function of the shadow price $\bar{w}_T$ rather than as a function of the acreage T:

$$r_{T,\theta,L} = -\frac{\alpha}{\beta}\frac{\bar{w}_T}{p} \qquad (16)$$

In fact, we have here the general expression for yield regardless of how the adjustment is made, with the shadow price identical to the price of land as perceived by the producer if the land factor can be optimally adjusted[3] (11*b*). Furthermore, if the farmer has less than optimal acreage, the shadow price $\bar{w}_T$ is higher than the price of land as perceived by the producer, given the overall convexity of the production set as assumed here. The fact that land is a fixed factor in the short run may therefore curb the potential decrease in yield.

Changes in grain yields are also strongly influenced by trends in land reallocation between farms, because the entire agricultural economy is adjusting to an overall production optimum that requires fewer and fewer farms.

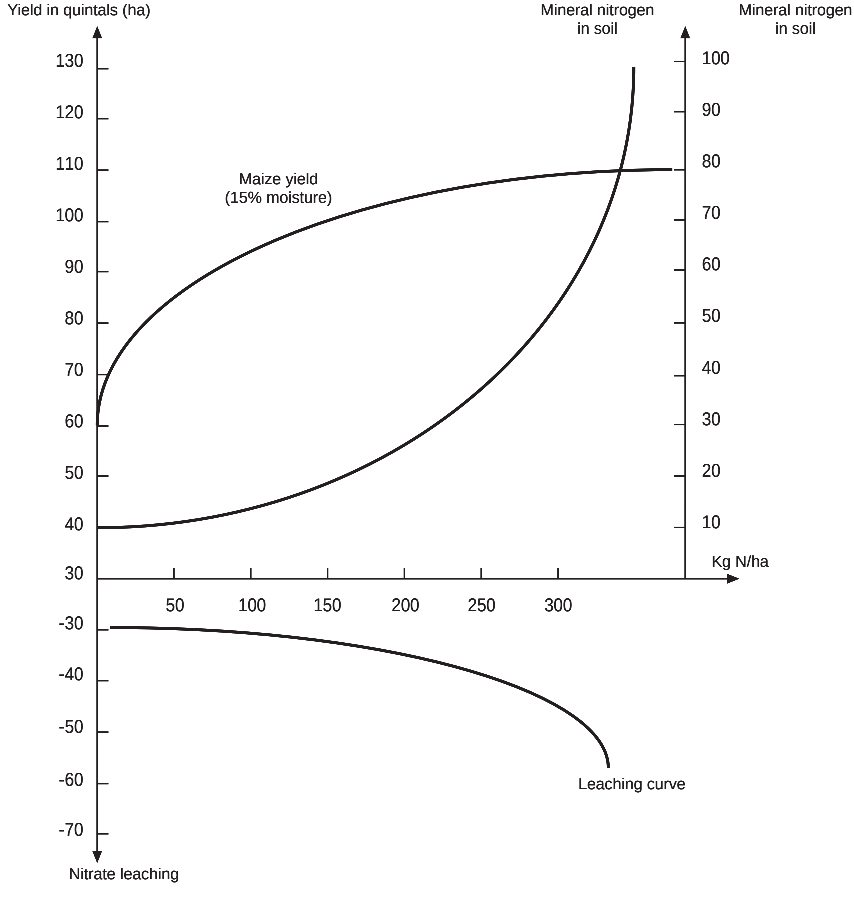
3.4. Optimal yield and the damage function

The higher yields achieved through irrigation do, of course, have implications for the environment. First, it should be borne in mind that the use of water for irrigation exerts pressures on other competing uses of water, thereby causing an initial set of environmental nuisances of excessively low water levels, eutrophication, and the salinisation or even depletion of groundwater. This paper will be confined to the environmental impacts stemming directly from farm irrigation, namely the groundwater transfer of nitrates and pesticides. These effects are first studied in graphical and then in analytical terms, through an integration of distortions relating to input costs and indirect commodity support through reference yields.

The higher yields achieved through irrigation do have environmental implications, of course. Agricultural research has shown that intensive, irrigation-based farming leads to major nitrogen losses. A simulation of maize monoculture in the rough soils of the Ariège *département*, using an EPIC model adjusted for local conditions, gives an indication of the phenomenon. An annual input of 250 kg nitrogen and 580 mm of water per ha gives a yield of 107 quintals per ha. This is accompanied by major nitrogen losses, with annual leaching of 193 kg per hectare (Cosserat, 1991). However, by reducing water input by over 100 mm and fertilisation by 50 kg, nitrogen losses can be cut by 31 per cent while still maintaining the same yield. This shows how the practices currently used are both harmful to the environment and sub-optimal for the farmer. It is a clear case of technical inefficiency.

Experimental work in Alsace (Koller, 1991) suggests a less adverse situation there. Figure 4 shows the maize crop response to fertilizer and nitrogen levels in the soil at a depth of 0.90 m. Assuming normal leaching, the lower part of the graph indicates nitrate losses. Clearly, leaching is heavily contingent upon soil and climate conditions, for a given level of fertilization.

Figure 4. **Maize yield, nitrogen left in soil and losses depending on nitrogen input (and estimated leaching curve)**



Source: Koller, 1991.

The agronomic research mentioned above demonstrates how complex it is to identify clearly the extent to which irrrigation aggravates this kind of nuisance, since weather conditions, soil quality and farming expertise all play a role. Nevertheless, we can begin by formalising three different impacts.

First, irrigation pushes up the agricultural yield, and this usually goes hand in hand with increased use of potentially polluting inputs: the damage function is expected to increase commensurately with the yield level. However, this depends on soil quality. Fertile land that is treated with fertilizer mobilises more nutrients for the crop than less fertile soil; consequently, there are fewer nitrate losses. It is therefore logical to approximate soil quality using the departmental reference yields that are used to calculate direct support and are based on actual grain yields from 1989 to 1992. Thus, for a given level of polluting inputs, it could be said that the higher the reference yield, the lower the environmental damage.

Finally, irrigation enables crops to achieve their maximum growth potential and thus mobilise nitrogen nutrients. This is the second impact of irrigation on the environment, but this time leading to less environmental damage at the margin; with the resulting damage function:

$$D\,(\ldots) = a\cdot r\,(w_x,\, p,\, r_{s,\,i},\cdot\cdot) - b\,(s,\, i)\cdot r_{s,\,i} \qquad (17)$$

$r_{s,\,i}$ denotes the reference yield (without or with irrigation respectively) while $b\,(s, i)$ is an adjustment factor with two values b_s and b_i depending on the growing method, and with $b_i > b_s$.

Generally, grain yield is both a major argument of the damage function and a price (as opposed to quantity) function of freely allocatable (as opposed to quasi-fixed) inputs. Using the Marginal Effective Tax Rate approach, it then becomes possible to measure the impact of price subsidisation (*vs.* factor rigidity) on subsequent trends in yield and hence environmental damage.

To illustrate this, let us look at the optimal yield obtained when the only fixed factor is land:

$$r_T = \left[\frac{1}{A}\left(\frac{p}{\alpha}\right)^{1-\gamma-\delta} T^{1-\alpha-\beta-\delta}\left(\frac{w_\theta}{\gamma}\right)^{\gamma}\left(\frac{-w_L}{\delta}\right)^{\delta}\right]^{\frac{1}{\alpha+\gamma+\delta-1}} \qquad (18)$$

Or, by fully differentiating:

$$dr_T = \left(\frac{\partial r}{\partial A}\right)dA + \left(\frac{\partial r}{\partial p}\right)dp + \left(\frac{\partial r}{\partial T}\right)dT + \left(\frac{\partial r}{\partial w_\theta}\right)dw_\theta + \left(\frac{\partial r}{\partial w_L}\right)dw_L \qquad (19)$$

(19) thus enables us to measure the impact on yield, and hence on the environmental damage function, of subsidised prices for agricultural factors and commodities. The partial derivatives of r_T in relation to A, p, T, w_θ, w_L are from equation (18). As mentioned above, the scalar A is strictly a function A $(w_x,\cdot)$, of other quasi-fixed factors of production such as capital (equipment and premises) and of

the price-vector w_x encompassing the variable factors. Of the variable factors, some benefit from subsidies or tax-breaks, such as for fuel, and others from a price well below the opportunity cost, such as for irrigation water. This gives:

$$dA = \sum_i \frac{\partial A}{\partial w_{x_i}} dw_{x_i} \qquad (19a)$$

The various terms of this differential are obtained by using Shephard's Lemma on the restricted cost function:

$$\frac{\partial CR}{\partial w_{x_i}} = x_i = y^{\alpha} T^{\beta} \theta^{\gamma} L^{\delta} \left(\frac{\partial A}{\partial w_{x_i}}\right) \qquad (19b)$$

When variable factor prices remain unchanged (dA = 0), then we have:

$$\frac{dr_T}{r_T} = \frac{1}{\alpha + \gamma + \delta - 1}\left[(1 - \gamma - \delta)\frac{dp}{p} + (1 - \alpha - \beta - \delta)\frac{dT}{T} + \gamma\frac{dw_\theta}{w_\theta} + \delta\frac{dw_L}{w_L}\right] \qquad (20)$$

In the case of incentives for more environmentally-friendly farm practices, this raises the possibility of substituting irrigation equipment and labour *ceteris paribus* via the taxation (*vs.* subsidisation) of associated prices such as:

$$\frac{dw_L}{w_L} = -\frac{\gamma}{\delta}\frac{dw_\theta}{w_\theta} \qquad (20a)$$

As mentioned previously in Section 2.2, irrigation through shared systems receives considerable support. The investment cost per hectare to supply water ranges in the upper ends from FF 30 000 to FF 50 000, depending on the size of the system and the user density. This is subsidised to about 60 to 80 per cent (AGPM, 1997), *i.e.* with an average support of about FF 28 000 per ha.

An initial econometric estimate of the corresponding production function [equation (8)] has been made, based on individual data from cereal farms, as described in Section 2.4. Unfortunately, not all of the parameters can be identified, partly because of lack of data on factor prices. So, taking into account equation (20a), a rise in the price of irrigation equipment of $\left(\frac{\Delta w_\theta}{w_\theta}\right) = 10\%$, combined with a fall in the cost of labour $\left(\frac{\Delta w_L}{w_L}\right) = 8.\dot{7}\%$, would leave the yield unchanged. It can also be assumed that this factor substitution would be beneficial to the environment.

Furthermore, taxation of chemical fertilizers may also provide an effective means of reducing the environmental damage in the medium and long terms, in particular through potential adjustments in labour and land factors. Such a policy can be evaluated through own and cross price elasticities, estimated from different cereal farm selected from the RICA (Rainelli and Vermersch, 1997). Table 7 is derived from a short-term analysis using the assumption that family work and land cannot be easily adjusted to variations in fertilizer prices.

Depending on the cropping system (single or multiple, with or without paid labour), the various price elasticities are fairly similar. In the short term, fertilizer demand is not very sensitive to its own price: a 10 per cent price increase would

Table 7. **Short-term price elasticities relative to inorganic nitrogen fertilizer prices**

	Fertilizer	Fuel	Capital	Paid labour
Single crop, with paid labour	–0.230	0.628	0.173	–0.135
Single crop, without paid labour	–0.283	0.532	0.150	–
Three crops, without paid labour	–0.287	0.597	0.156	–

lead to a fall in demand of only 2 to 3 per cent. This fall would be accompanied by substitution in favour of fuel and capital: for instance, greater machinery use and fractioning of inputs, assuming there would be some labour flexibility over time.

The estimation of a tobit model for the allocation of family and paid labour (Table 8) allows a medium-term situation to be envisaged, featuring a possible adjustment of the labour factor following fertilizer taxation. Compared with Table 7, the own price effect is more marked, confirming the logic of the Le Chatelier-Samuelson Principle. The fall in demand would be about 4 per cent. Although the substitutability relation with capital is not significant, that with fuel and labour remain sensitive. This could lead to the resumption of higher organic fertilizer treatments (manure and sewage inputs), which technically would require extra fuel and labour.

Table 8. **Price elasticities for fertilizer using the labour allocation tobit model**

	Fertilizer	Fuel	Capital	Labour
One crop	–0.438	0.473	0.078	0.202

The inference of long-term levels for family labour and land would enable potential extensification trends, induced jointly through lower fertilizer consumption and a corresponding increase in the surface areas utilised.

Table 9 shows that own price effects are even higher than previously, providing even more confirmation for the Le Chatelier-Samuelson Principle: the taxation of nitrogen fertilizers would have a greater impact on demand the more all factors adjust to their optimum level. In the long term, capital and fertilizer also seem to be complementary, as a corollary to extensification. This results in fertilizer and land substitutability.

Table 9. **Long-term price elasticites relative to fertilizer prices**

	Fertilizer	Fuel	Capital	Labour	Land
Single crop, fixed labour	–0.630	0.228	–0.220	–	0.054
Single crop, no fixed labour	–0.521	0.256	–0.119	0.940	0.045
Single crop, no fixed labour, land and labour optimal	–0.634	0.307	–0.022	0.047	1.025
Three crops, no fixed labour, land and labour optimal	–0.646	0.238	–0.203	0.324	0.119

3.5. How socially efficient are irrigation subsidies?

Government support for irrigated farming until May 1992 mainly took the forms of equipment funding and preferential rates for water. The CAP reform then stepped up this type of support by using the reference yields for irrigated crops to determine direct payments per hectare. These are "second-best" instruments when it comes to supporting farm incomes and they also carry a certain risk, given the indirect impacts they have on other markets, such as for land and water.

The fact that policymakers grant direct payments based on acreage for irrigated crops can be construed as a production right, implicitly entitling farmers to use water resources. As such, how should this be construed in terms of the expected social efficiency?

Support for irrigated crops under the 1992 *reform*

The 1992 CAP reform had three main objectives. Controlling the supply of cereals and oilseed was one of the leading short-term aims, with a view to stabilising the European Union's farm budget. The second aim was to reduce the negative externalities of agriculture stemming from intensification. This required lower commodity prices, but could be somewhat assisted by set-aside schemes. The third objective was to maintain the economic viability of farms. To achieve this, the reform granted deficiency payments to farmers commensurate with the acreage under crop and land that was set-aside, cushioning the blow of the reforms and just managing to maintain income scales in the sector. In line with this objective, irrigated reference yields were used to calculate payments in combination with the ceiling on departmental acreage entitling farmers to that support. But, as with set-aside, these irrigation measures run counter to the objective of reducing agricultural intensification and its associated negative externalities. Instead, they appear to embody a determination to preserve the economic viability of certain intensive systems, possibly under pressure from farm lobbies.

But such support is not risk-free in the long term. These direct payments based on acreage can be construed as regionally differentiated property rent; the medium-term risk is that the rent might be captured in land transactions, as we have seen has happened with the production rights associated with the milk quotas. In the more fortunate areas (those with high historical reference yields), this land rent may curb any future productivity gains. In the less fortunate areas, the low level of support is bound to increase and crowd out labour. Specific support for irrigated crops is bound to make this rent more widespread, because the level of support is higher than for non-irrigated cereals.

Furthermore this support is probably based on water prices that underestimate the social value of this multi-use resource (see below). In other words, government support, in the form of a land rent for irrigated land, carries a surplus because the price charged for irrigation water is already lower than its social value. Clearly this is a case of inefficient resource allocation caused by government support to agriculture.

Irrigated crop support and externalities

By and large, the CAP reform can be characterised by the transition from price support to income support through direct payments. For cereals, the support is proportional to crop acreage, including land for set-aside, and is used to offset the fall in prices. This does not encourage farmers to adopt low-intensity ("extensive") practices, since the incentive is offset by the obligation on large producers to set aside land, *i.e.* produce less on a proportionally smaller acreage. Set-aside may have the opposite effect to taxing fertilizers when it comes to encouraging less intensive farming. It ends up curbing the substitution of polluting inputs by land extension, all the more so in that this supply-side management tool usually leads farmers to set aside their less fertile land, focusing all the inputs on the best, and generally irrigated, land.

Let us now look at the new forms of government support for agriculture. Far from supporting positive externalities, they in fact remunerate based on the land rent differential, which amounts to freezing intensive farming at its current level. In this respect, irrigation is a good example. Prior to the reform, price support provided an incentive to intensify farming, in particular through the development of irrigated maize. The fall in cereal prices intended by the reform should have made this crop relatively less profitable, and thus reduced the negative externalities associated with it (nitrate leaching and excessively low water-levels) and increased the positive externalities stemming from incentives to move to low-intensity systems. However, setting a specific reference yield for irrigated crops maintains, to some extent, the remuneration of the pecuniary externality that price support formerly provided for irrigation, in the form of a lump-sum rent per hectare of irrigated land. This is detrimental to rain-fed crops since there is a separate reference yield for irrigated crops but no increase in the overall compensatory grant for the *départements* concerned. There is merely a change in the way support is distributed between crop systems. Furthermore, as we have seen, in some *départements* the application of a ceiling on acreage has enabled newly irrigated land to benefit from irrigated reference yields.

Optimal yield, reference yield and implicit water prices

The above model, used to evaluate the private returns on irrigation investment, also sheds some light on the question of social returns. This is demonstrated below.

The restricted cost function which was employed above to represent the irrigation technology used now includes ω_e the price of water, a resource deemed to be a variable factor. We shall leave aside the share of irrigated land θ, assuming that it equals one, to keep the calculation simple. Prior to CAP reform, the producer was assumed to be maximising his short-term profit (with land and labour being fixed), that is to say, going back to the previous notation with a private unit cost of water to the farmer equal to $\bar{\omega}_e$ we have:

$$\underset{y}{Max}\ p_0 y - A(\bar{w}_e,\cdot) y^{\alpha} T^{\beta} L^{\delta} \quad (21)$$

Hence, the optimal supply and yield y_0 and r_0 are:

$$y_0 = \left[\frac{p_0}{A(\bar{w}_e,\cdot)T\alpha^{\beta}L^{\delta}}\right]^{\frac{1}{\alpha-1}} \text{ and } r_0 = \left[\frac{p_0}{A(\bar{w}_e,\cdot)T\alpha^{\alpha+\beta-1}L^{\delta}}\right]^{\frac{1}{\alpha-1}} \quad (22)$$

The private unit cost of water to the farmer $\bar{w}_e$ is lower than its social unit value w_e^s for two main reasons. First, the investment required to mobilise water resources has until now been largely subsidised and, secondly, the total cost (cost to the farmer plus subsidies) does not include any harmful effects of irrigation on the natural environment (salinisation, fertility loss), or the opportunity costs that relate to other uses of the water that compete with irrigation.

The cereal component of the CAP reform leads to a price $p_1 < p_0$ and direct support indexed by a reference yield r_i, which gives a programme of maximisation:

$$\underset{y}{Max}\ p_1 y - A(\bar{w}_e) y^{\alpha} T^{\beta} L^{\delta} + (p_0 - p_1)\cdot r_i \cdot T \quad (23)$$

As direct support does not affect the optimisation, the expression of optimal yield is analogous to (22):

$$r_1 = \left[\frac{p_1}{A(\bar{w}_e)\alpha T^{\alpha+\beta-1}L^{\delta}}\right]^{\frac{1}{\alpha-1}} \quad (24)$$

It is also important to compare yields prior to the reform r_0, reference yields r_i and the post-reform yields r_1. Reference yields for irrigated crops are determined in the same way as for non-irrigated cereals: *i.e.*, a historical average yield is estimated over five years and is smoothed and weighted (two-thirds departmental, one-third national average). It is then reasonable to assume that $r < r_0$. In theory, it is hard to compare r_i and r_1.[4] That being so, efforts to achieve compatibility between CAP reform and the agricultural component of the GATT are based on the assumption that post-reform yields will not exceed the reference yields, leading to the following inequalities:

$$r_1 \leq r_i \leq r_0 \quad (25)$$

Generally, equation (24) links the optimal yield to the price of water as perceived by the farmer; more specifically, the reference yield *ri* is a post-reform optimal yield for a given water price of $w_e^{r_i}$:

$$r_i = \left[\frac{p_1}{A(w_e^{r_i})\alpha T^{\alpha+\beta-1} L^{\delta}}\right]^{\frac{1}{\alpha-1}} \quad (26)$$

Hence, going back to inequality (25):

$$w_e^{r_i} \leq \bar{w}_e \leq w_e^s \quad (27)$$

In other words, the reference yield includes an implicit water price that is lower than the private unit cost to the farmer and therefore lower than the social value of the water. This amounts to an implicit acknowledgement that agricultural production rights take precedence over other water uses or resource preservation.

4. CONCLUSIONS

Government support for irrigation comes in the form of subsidies to alleviate factor costs. It also takes the form of preferential rates for access to water. By considering reference yields as target yields for farmers, direct support for irrigated crops not only provides a land rent but is also based on water prices that underestimate the social value of this natural resource. Given the various forms of irrigation support that farmers have been receiving, it is likely that the private unit cost of water has been lower than its marginal social cost. The microeconomic model presented in this paper shows that the 1992 CAP reform made the situation worse by fixing, via the reference yields for irrigated crops, an even lower implicit price for irrigation water.

The empirical findings highlight the increase in private profitability generated by all forms of direct and indirect support for irrigation in France, which explains the steady rise in irrigated land. This automatically leads to the increased use of all kinds of polluting inputs, even if irrigated crop systems prove to be technically more efficient than non-irrigated ones. Whether these systems are more efficient, all things being equal, remains to be proven.

Thus, the right to irrigation use in agricultural production, as acknowledged and remunerated by direct support, appears to take precedence over other direct or indirect uses of water resources. This is a clear example of property rights being allocated that favour intensive farming rather than protecting the environment (OECD, 1996). This order of priority, always respected by policymakers, is aimed at remunerating, and hence preserving, the pecuniary externalities, *i.e.*, concentrating certain forms of agricultural production, maintaining cost-competitiveness, restricting budgets, etc.

The scope for support to be capitalised into land values reinforces this trend. Already in the Landes *département*, where over 40 per cent of arable land is irrigated, the increase in land prices since 1994 has been almost twice as high as the national average. A similar trend has been recorded in other *départements* in south-west France with an equally high share of irrigated land.

In September 1997, when proposing a new approach to the allocation of cereal premia and an end to support for irrigated crops,[5] the French Ministry of Agriculture met with strong opposition from farming organisations. The proposal is nevertheless in line with a new rationale for government support that is more equitable and less harmful to the environment. It is important to note that this arrangement, coupled with lower grain prices, is in keeping with the Marginal Effective Tax Rate approach and is proving to be better targeted than taxes on inputs. This is because, by discouraging the capitalisation of support into land prices and hence intensification, it is contributing to the emergence and expansion of sustainable agriculture. However, it must be accompanied by incentives to use factor mixes that lead to the joint production of environmental amenities capable of curbing the steady crowding-out of agricultural labour. It may be better to start encouraging and subsidising economies of scope obtained by combining environmentally-friendly forms of agriculture rather than the economies of scale and specialisation that come with ever-larger farms. It would mean redefining property rights, but could prove less onerous in transaction costs than complex new tax schemes for the use of irrigation.

Notes

1. The inequality (7) (implies decreasing returns to scale along the expansion path only.
2. France has opted for a reference yield that is the weighted average of the national yield (1/3) and the departmental yield (2/3).
3. (11) can also be written as follows: $\underset{T}{Max}\ \Pi R(p, A, T, \theta, L) - (w_T + w_\theta \theta)T$ with, as the necessary first-order condition: $\left.\frac{\partial \Pi R}{\partial T}\right|_{\theta, L} = w_T + w_\theta \theta$ or an equality between the shadow price and the price of the land as perceived by the producer (the direct payment per hectare could thus be subtracted).
4. The stated aim of the reform is to fully offset the fall in prices, which in theory implies $\Pi R\ (p_0,\cdot) = \Pi R\ (p_1,\cdot)$; knowing the values of p_0 and p_1 and a possible estimation of the parameter α, we are likely to obtain $r_i > r_1$ in most cases.
5. Proposal by Mr. Louis Le Pensec, French Minister of Agriculture, to the National Council of the FNSEA (Fédération nationale des syndicats d'exploitants agricoles, or national federation of farmers' unions) on 3 September 1997 (in AGRA Presse, 8 September 1997, No. 2627).

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Environmental Effects of Changes in Taxation and Support to Agriculture

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SUMMARY OF RESULTS AND POLICY IMPLICATIONS

Changes in the relative prices of inputs used by agriculture (by taxes and/or subsidies) may not be sufficient alone to reduce agricultural pollution, because they will not be as efficient as targeted levies or directed agricultural support measures in this task. Additional budgetary policies or polciies directed towards reducing production surpluses may also be required.

Nitrogen balances could be used to indicate the responses by the agricultural sector to environmental policies, in terms of adjustments to farming practices and farm management. Nitrogen balances can also be used to assess the beneficial effects of changes in farm behaviour on the environment and agriculture. In the Netherlands, nutrient balance levels provide an appropriate indicator of responses by the agricultural sector to policy changes, as well as a reasonable measure of changes in nutrient levels in reaction to changes in water quality. In comparison, indicators of input use (*e.g.*, the use of mineral fertilizers and feed concentrates) or agronomic practices can provide only limited information about their likely effects on the environment. Nitrogen balances can be used to target levies on the actual environmentally-polluting activities, and/or to provide incentives for environmentally-friendly activities.

The practical use of economic instruments (*e.g.*, taxes, subsidies and levies) in agri-environmental policy depends on the transaction costs involved (implementation, enforcement and monitoring) and the relationship to the site-specific natural conditions. A balance needs to be reached between the precision of a certain policy instrument (targeted to reducing emissions to the environment) and the public resources required to implement and enforce such a system. The implementation and monitoring costs (transaction costs) are important for an assessment of the cost-effectiveness of the environmental policy tool.

The impact of taxes on the inputs used by agriculture, and thus the achievement of environmental objectives, remains rather uncertain. A tax which contributes to the achievement of environmental targets in a more direct manner is, therefore,found to be more efficient than a tax on inputs. Compared to a tax on input use, a tax on nitrogen surplus would provide an incentive to use nitrogen from animal manure more efficiently.

The possibility of achieving more sustainable production methods through the adjustment of VAT rates was found in this study to be rather limited.

1. INTRODUCTION

The main objective of this report is to compare two different modes of agricultural production, notably input intensive and input extensive production, with respect to the tax and support treatment they receive, their potential environmental effects and the incomes they generate for farmers.

Ideally this would require the examination of one product that is produced both intensively and extensively with respect to environmentally relevant inputs – like fertilizers, pesticides or energy use – and to investigate what proportion of the selling price of the finished product is made up of the total net amount of taxes minus support. Such an analysis would reveal whether the prevailing taxes and support measures (taken together) discriminate against the extensively produced product. These calculations are, however, rather complicated, especially when it comes to assessing the net effective tax rate. This study therefore opts for a more limited objective, but stays as close as possible to the basic idea in executing the research. Thus, the present analysis assesses the impact of taxes and subsidies on the use of agricultural inputs (*e.g.*, livestock manure, fertilizers, and feed concentrates), production and land use.

In order to assess the effects of agricultural support measures on input use and the environment, a tax on the use of nitrogen inputs is used as a proxy for an increase in input prices when the commodities are traded on several markets (*i.e.*, the manure market). This analysis shows how changes in relative prices would be reinforced or countervailed by these market mechanisms. The impacts of changes in the relative prices of the inputs used on the intensity of production, and the utilisation of land and inputs, are assessed.

One of the basic assumptions of the project is that the sensitivity of environmental effects to input prices and support measures that affect farm incomes might be significant compared with charges and taxes on pollution, which are also difficult to administer and enforce. It would therefore be interesting to compare the effectiveness of a tax on nitrogen surpluses with an increase in the taxation of nitrogen consumed by agriculture through fertilizer and feed concentrates, for example by raising the VAT on agricultural products. Essentially, this report compares the effects on agriculture and on the environment of putting a tax on either the nitrogen inputs used or on the emissions produced (*i.e.*, the nitrogen surplus). In adition, a qualitative approach is also applied in the report to explore the potential effects of changing VAT rates according to the production methods applied. The option of applying a lower VAT rate to meat produced with sustainable production methods than to meat produced with regular production methods is evaluated. Such a tax differentiation might compensate for the higher production costs of production methods which achieve certain sustainability criteria, compared with meat produced according to regular production methods.

The objective of the report is to explore cost-effective means of achieving less intensive agricultural production systems in the Netherlands. An assessment of the effects on agriculture (including agribusiness) and the environment is undertaken through an examination of the effects of putting a tax on inputs used (in terms of fertilizers and/or feed concentrates) or a tax on emissions produced (*e.g.*, nitrogen surplus). A sensitivity analysis (with a gradual increase in the tax rates) indicates the responses by the agricultural sector to such policy instruments. A distinction is made between two types of inputs – fertilizers for crop production and feed concentrates for livestock production – to explore their different effects on agriculture (production intensity and income) and the environment (nitrogen surpluses).

The analysis provided in this report is based on a Dutch Regionalised Agricultural Model (DRAM), which is a partial equilibrium, regionalised, comparative static model of the agricultural sector. The model allows an identification of least-cost options in the agricultural sector for applying nutrients available from various sources (feed concentrates, mineral fertilizers, livestock manure), according to the price relationships of the inputs used (depending on taxes and subsidies) and the prevailing standards of nutrient application. Further details on the model are provided in the Annex to the report.

2. CONTROL OF NITROGEN POLLUTION FROM AGRICULTURE IN THE NETHERLANDS

The structure of the agricultural sector of the Netherlands can be characterised by:

- livestock production is concentrated in the sandy regions of the southern and eastern parts of the country;
- crop production is rather concentrated in the clayey regions in the northern and south-western parts;

– livestock production in both cattle farming and the intensive livestock industry (mainly pigs and poultry) depend largely on feed concentrates which are imported from abroad.

Excess quantities of manure are produced at livestock holdings as a result of prevailing legislation. Part of the livestock manure is applied to the own holding, and excess amounts are either transported to neighbouring holdings with a lower stocking for fertilisation, or may be exported to surrounding countries for processing in factories. Some is also transported to other regions, but this accounts for only 40 per cent of total manure surplus at the farm level (Brouwer *et al.*, 1996). However, the costs involved in such transport are of course substantially higher than the costs involved in applying the manure within the region. It is a combination of relative prices that has contributed to the large amounts of manure surplus, the high levels of mineral surpluses, and the excess amounts of nitrogen compared with the amount that could be taken up by crops. Arable crop production, for example, is based to a large extent on purchased mineral fertilizers. This is due primarily to the relatively low livestock density in these regions, and thus the rather large transportation costs of animal manure from the manure production areas, and the relatively low prices of mineral fertilizers.

To reduce manure and mineral surpluses, manure quotas and application regulations have been introduced in the Netherlands in the past. These will be tightened in the future. Consequently, the export of manure to regions with low livestock densities may increase, or livestock production might be reallocated to these regions. Other options to improve nitrogen pollution control include improvements in the feed efficiency of minerals, alterations in fertilisation strategies, and changes in land use and the composition of livestock.

Responses by the agricultural sector to meet environmental targets increasingly require expenditures on investments and environmental taxes (see Table 1). The total costs of meeting agri-environmental requirements increased between 1988 and 1994, from 140 to 460 million Dfl. About three quarters of these expenses related to manure disposal, storage and spreading. The share of environmental costs in net value added also increased during recent years, from 1.3 per cent in 1988 to 3.6 per cent in 1994.

Understanding agricultural input and output markets is essential for determining economic efficient solutions to the problems of manure and mineral surpluses. This paper presents a wide-ranging analysis of these markets and the subsidies and tax incentives that might hinder sound environmental practices, as well as examining the costs and benefits of reducing or eliminating them. The paper also provides empirical data for more general recommendations and policy conclusions. Finally, the social-economic consequences are taken into account as well.

Table 1. **Environmental costs to the agricultural sector in the Netherlands**
Million Dfl

	1988	1990	1992	1994
Environmental costs (a)	139	204	330	459
Environmental taxes (b)	48	88	164	117
Total (c = a + b)	187	292	494	576
Subsidies received (d)	31	54	74	91
Net total environmental costs (e = c – d)	156	236	420	485
Share of net costs in net value added	1.3	1.6	3.2	3.6

Source: Silvis and Van Bruchem, 1996.

3. NITROGEN POLLUTION CONTROL BY TAXING INPUTS

The impact of two types of taxes are explored in this section: a tax on nitrogen in fertilizers and a tax on nitrogen in feed concentrates, as well as a tax on both inputs.

Tax on fertilizers

The inclusion of the tax on mineral fertilizers in the model in kg N (nitrogen) is relatively easy. The following equation is used:

$$pk = pkm + h,$$

where pk is the price of nitrogen in mineral fertilizers paid by the users of the mineral fertilizers, pkm is the market price of nitrogen in mineral fertilizers and h is the tax on nitrogen in mineral fertilizers.

Several important assumptions are made in the model calculations, including that:

– the market price of nitrogen in mineral fertilizers is fixed exogenously;

– the upper limit on the use of nitrogen from animal manure on arable land is determined by conditions in the base period;

– there are limited possibilities to increase livestock production in the manure concentration areas due to the existing manure quota system and legislation regarding the application of livestock manure on agricultural land (in terms of kg P per ha per crop);

– the exogenous workability of nitrogen in animal manure; and

– the absence of continuous crop specific yield functions between yields per hectare and the usage of nitrogen per hectare especially in the arable farming sector.

A tax on nitrogen in mineral fertilizers will have a limited impact on nitrogen surpluses. Nitrogen surplus at soil level was found to be reduced only after a tax rate of more than 3 Dfl per kg N now applied. This means that the demand for mineral fertilizers is very inelastic under a system of relatively low tax levels.

Two conditions were important in determining this low elasticity. The most important was the relatively high prices for beef cattle and dairy cows in the base period. As a result, there were limited incentives to change fertilizer strategies under the given market conditions. Under such conditions, farmers may prefer to pay the tax levy rather than risk income losses by restricting their use of inputs. The second relevant condition was the relatively high prices for feed concentrates. This also limited the options for lowering nitrogen surpluses by adjustments in thefer-tilisation regimes. A reduction in the use of mineral fertilizers would lower tax payments in cattle farming. These savings, however, would be partly offset by an increase in the use of purchased feed concentrates and increasing prices of fodder crops brought about by the decrease in supply.

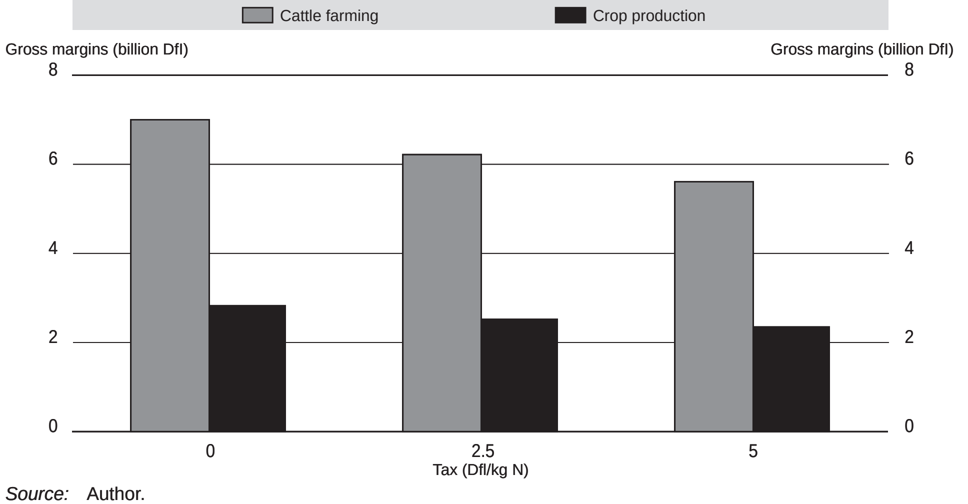
A tax rate of 5 Dfl per kg N was assumed, resulting in a decrease in the surplus of nitrogen by about 11 per cent. Given a very inelastic demand for mineral fertilizers, the effect of a tax on mineral fertilizers on the gross margins from agriculture will be very high. It was found that a tax rate of 5 Dfl per kg N will lead to a decrease in the gross margins from agriculture of about 14 per cent, because expensive measures would need to be taken to maintain production levels. The largest economic effects were calculated for the cattle farming sector and the arable production sector (Figure 1).

Gross margins in these activities were calculated to decrease respectively by 20 and 17 per cent. Gross margins in the intensive livestock sector were unaffected. There, a small increase in the gross margins might even be possible through an increase in the demand foranimal manure and the resulting higher animal manure prices.

Expected revenues from the tax on nitrogen fertilizers would be substantial. Taxes paid by the agricultural sector would increase from about 186 mln Dfl (under a tax rate of 0.5 Dfl per kg N) to 1 530 mln Dfl (with a tax rate of 5 Dfl per kg N). The total amount of producers' surplus (generated by the agricultural sector) and public budget (as a rough indicator of the welfare effects) would decrease by approximately 250 mln Dfl.

The effects on livestock composition and land use of a gradual increase in the tax on mineral fertilizers are presented in Tables 2 and 3. Table 2 shows trends in livestock composition under different tax rates. Compared to the base case, the number of dairy cows and beef cattle would decrease respectively by 13 and 9 per cent under a tax rate on mineral fertilizers of 5 Dfl per kg N. Under such conditions,

Figure 1. **Gross margins in cattle farming and crop production with different tax rates on mineral fertilizers**



Source: Author.

there might be a limited increase in finishing pigs and sows and a relatively large increase in poultry, due to the relatively high nitrogen content of their manure. Table 3 shows a decrease in the acreage of potatoes. This is due to the relatively high nitrogen demand of potatoes.

Table 2. **Livestock composition under different tax rates on nitrogen in mineral fertilizers**

Average numbers per year, mln

Tax rate (Dfl per kg N)	Dairy cows	Beef cattle	Meat calves	Finishing Pigs	Sows	Poultry[1]
0.0	1.6	1.1	0.62	7.1	1.28	76.6
2.5	1.6	1.1	0.62	7.2	1.28	79
5.0	1.4	1.0	0.59	7.2	1.28	81

1. Excluding laying hens younger than 18 weeks.
Source: Own calculations.

Table 3. **Land use under different tax rates on nitrogen in mineral fertilizers**

1 000 ha

Tax rate (Dfl per kg N)	Fodder crops			Arable land		Other
	Grass	Maize	Total	Cereals	Potatoes	
0.0	1 077	207	1 284	188	161	281
2.5	1 067	214	1 281	189	153	291
5.0	1 071	214	1 285	189	147	293

Source: Own calculations.

Tax on feed concentrates

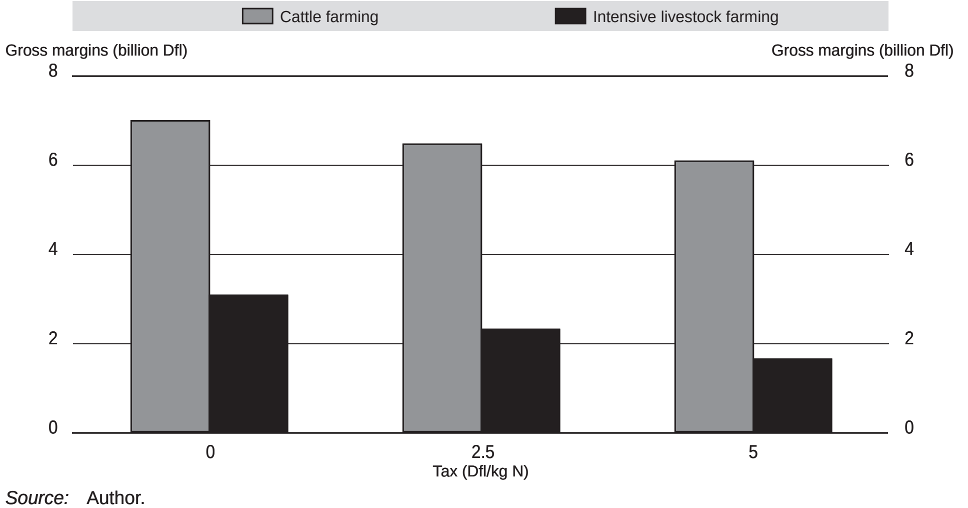
A tax on nitrogen in feed concentrates could contribute to a replacement of feed concentrates by fodder crops produced locally, and subsequently to an improvement in the balance between the inputs supplied and the inputs used by the agricultural sector. Such a tax, however, would have very little impact on the nitrogen surpluses at soil level. In comparison with the reference situation, a tax rate of 5 Dfl per kilogram N on feed concentrates would result in a decrease in the nitrogen surplus at soil level by about 7 per cent, but gross margins from agriculture would be expected to decrease by about 17 per cent. Thus, a more than proportional reduction in the gross margins would result compared with the reduction innitrogen surplus. Furthermore, the decrease in gross margins would be unequally distributed between agricultural sectors.

Figure 2 shows the relationship between the tax level on nitrogen in feed concentrates and the gross margins in the cattle farming and the intensive livestock sectors.[1]

This shows that a tax rate of 5 Dfl per kilogram N in feed concentrates decreases the gross margins in the cattle farming sector by about 13 per cent compared with the reference situation. Under the same tax rate, gross margins in the intensive livestock sector decrease by 47 per cent. This difference in the economic effects of a tax on feed concentrates can be fully explained by differences in the share of feed concentrates in total feed use in the cattle farming sector compared with the intensive livestock sector.

The budgetary effect for the government would be expected to be large. Taxes paid by the agricultural sector would increase from about 230 million Dfl under a tax rate of 0.5 Dfl per kg N to 2 100 million Dfl under a tax rate of 5 Dfl per kg N. A rough indication of the welfare effects of the tax change would be to compare the sum of the producer surplus and the budget effect before and after the introduction of the tax.[2]

Figure 2. **Gross margins in cattle farming and intensive livestock production with different tax rates on nitrogen in feed**



Source: Author.

The effects of a gradual increase in the tax on feed concentrates on livestock composition and land use are presented in Tables 4 and 5. The number of dairy cows and beef cattle would remain rather stable, regardless of the tax level (Table 4). But the number of pigs and poultry would be expected to decrease dramatically. Under a tax rate of 2.5 Dfl per kg N, the decline in the average numbers of pigs and poultry per year would be equivalent to about 10 and 19 per cent respectively.

Table 4. **Livestock composition under different tax rates on feed concentrates**

Average numbers per year, mln

Tax rate (Dfl per kg N)	Dairy cows	Beef cattle	Meat calves	Finishing pigs	Sows	Poultry[1]
0.0	1.6	1.1	0.62	7.1	1.28	76.6
2.5	1.6	1.1	0.59	6.4	1.16	62.3
5.0	1.6	1.0	0.56	5.7	1.04	61.8

1. Excluding laying hens younger than 18 weeks.
Source: Own calculations.

Table 5. **Land use under different tax rates on nitrogen in feed concentrates**

1 000 ha

Tax rate (Dfl per kg N)	Fodder crops			Arable land		Other
	Grass	Maize	Total	Cereals	Potatoes	
0.0	1 077	207	1 284	188	161	281
2.5	1 065	207	1 272	189	163	290
5.0	1 051	207	1 258	196	166	294

Source: Own calculations.

Table 5 shows the decrease in the acreage of fodder crops resulting from the tax on feed concentrates, mainly as a result of a decrease in the area of grassland. The acreage of arable crops was estimated to increase by about 4 per cent under a tax rate of 5 Dfl per kg N compared with the reference situation.

Tax on fertilizers and feed concentrates

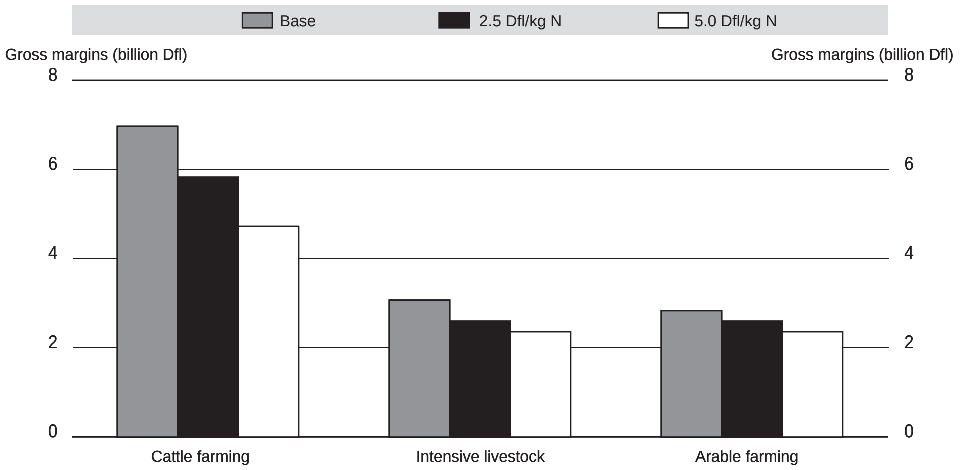
Under this scenario, a tax on nitrogen in mineral fertilizers is combined with a tax on nitrogen in feed concentrates. As explained before, the tax on nitrogen in feed concentrates is incorporated in the objective function of the model to maximise national profits from agriculture. Itis necessary to recalculate the parameters of the quadratic cost functions or to add a linear term to the linear cost functions used for grazing livestock. The total price of nitrogen in mineral fertilizers is calculated as the sum of the market price of nitrogen in mineral fertilizers plusd the tax rate on nitrogen in mineral fertilizers.

The impact on the environment of the combined tax on inputs is comparable to either a tax on nitrogen in feed concentrates or nitrogen in mineral fertilizers only. The additional gains to the environment are limited. Under a tax rate of 5 Dfl per kg N, the nitrogen surplus at soil level decreases from 407 million kg N in the reference or base situation to 370 million kg N. This is equivalent to a reduction of 9 per cent.

Substitution possibilities are limited when this combined tax is applied, thus putting additional constraints on the gross margins achieved in agriculture. Figure 3 shows a decrease in gross margins from about 12.8 billion Dfl in the reference situation to 8.7 billion Dfl under a tax rate of 5 Dfl per kg N on both nitrogen in feed concentrates and nitrogen in mineral fertilizers. This is equal to a decline of about 32 per cent in gross margins.

Under a tax on nitrogen in feed concentrates only, the arable sector could possibly increase margins and under a tax on nitrogen in mineral fertilizers the

Figure 3. **Gross margins in the cattle farming sector, the intensive livestock sector and the crop production or arable sector under different tax rates on nitrogen in feed concentrates and mineral fertilizers**
Billion Dfl



Source: Author.

intensive livestock sector could increase their margins. All sectors lose under a combined tax, but the losses are unequally distributed. This is shown in Figure 3. Under a tax level of 5 Dfl per kg N, the cattle farming sector loses 32 per cent of its gross margins in the reference situation, the intensive livestock sector loses 46 per cent and the arable sector 17 per cent.

The budget could be expected to increase by 3 900 million Dfl under a tax level of 5 Dfl per kg N on feed concentrates and mineral fertilizers. Net costs to the public and private sector (agriculture) in total would amount to approximately 190 million Dfl.

The expected impact on livestock composition is presented in Table 6. The impacts of the combined tax on livestock composition are comparable to those under a tax on nitrogen in feed concentrates only. The number of animals in the intensive livestock sector would be slightly less affected under a combined tax, compared with a tax on nitrogen in feed concentrates only.

The combined tax would lead to a reallocation of grassland to arable land, primarily low nitrogen input crops (Table 7). The acreage of potatoes would slightly decrease.

Table 6. **Livestock composition under different tax rates on nitrogen in feed concentrates and nitrogen in mineral fertilizers**

Average numbers per year, mln

Tax rate (Dfl per kg N)	Dairy cows	Beef cattle	Meat calves	Finishing pigs	Sows	Poultry[1]
0.0	1.6	1.1	0.62	7.1	1.28	76.6
2.5	1.6	1.1	0.60	6.5	1.17	62.3
5.0	1.6	1.0	0.57	5.9	1.07	61.8

1. Excluding laying hens younger than 18 weeks.
Source: Own calculations.

Table 7. **Land use under different tax rates on nitrogen in feed concentrates and nitrogen in mineral fertilizers**

1 000 ha

Tax rate (Dfl per kg N)	Fodder crops			Arable land		Other
	Grass	Maize	Total	Cereals	Potatoes	
0.0	1 077	207	1 284	188	161	281
2.5	1 058	213	1 271	190	157	296
5.0	1 034	216	1 250	197	154	313

Source: Own calculations.

4. NITROGEN POLLUTION CONTROL BY TAXING EMISSIONS

In this scenario, the tax is placed on nitrogen surplus, including the emission of nitrogen as ammonia during application. It should be noticed that this surplus is different from what we have called nitrogen surplus at the soil level.

The nitrogen surplus, including the emission of nitrogen as ammonia during application, is calculated as:

$$\Sigma\ \mathrm{ORGMEST}_{t'\,tr} + \Sigma\ \mathrm{KUNSTMEST}_{t} - \Sigma\ afvoer_{tr}\ \mathrm{X}_{tr} = \mathrm{MINBALANS}_{r}$$

Where:

$\mathrm{ORGMEST}_{t'\,tr}$ = Application of nitrogen from animal manure of type *t'* to activity *t* in region *r*, including grazing (1 000 kg).

$\mathrm{KUNSTMEST}_{tr}$ = Application of nitrogen from mineral fertilizers to activity *t* in region *r* (1 000 kg).

$afvoer_{tr}$ = Uptake of nitrogen by activity *t* in region *r* (kg per hectare).

X_{tr} = Activity *t* in region *r* (1 000 hectare).

$MINBALANS_r$ = Nitrogen balance, including emission of nitrogen as ammonia during application in region *r* (1 000 kg).

A "levy-free zone" (threshold level) of 200 kilograms of nitrogen surplus per hectare on grassland and 150 kilograms of nitrogen surplus per hectare on arable land is assumed. A levy will only need to be paid in case nitrogen surpluses exceed these levy-free zones. The levy-free zones are taken from actual policy proposals of the national government for the year 2005.

Under these conditions, a levy of 5 Dfl per kg N on nitrogen surpluses results in a decrease in the nitrogen surplus at soil level of 11 per cent. In conjunction with this decrease in nitrogen surpluses, gross margins from agriculture would be reduced by 5 per cent as well. The decrease in gross margins in the intensive livestock sector would mainly result from income transfers to the cattle farming sector, and in the arable sector through changes in manure prices (see Table 8). Income losses in the intensive livestock sector would equal about 23 per cent. The cattle farming sector may be favourably affected because they own land to grow fodder crops, so this sector would be hardly affected by the tax. The arable farming sector would also be affected only to a small extent (Figure 4).[3]

The government revenues from taxing nitrogen emissionscan be expected to be much lower than those from taxes on nitrogen in feed concentrates or mineral fertilizers. Under a 5 Dfl per kg N tax rate on nitrogen surpluses, the budgetary effect would be an additional 470 million Dfl. Nevertheless, the effects on societal welfare, calculated as the sum of the changes in the budget and the producers' surplus in agriculture, would be expected to decrease by 230 million Dfl.

Changes in livestock composition from a nitrogen surplus tax are presented in Table 9. With respect to grazing livestock, dairy cows and beef cattle, the developments under different tax rates on nitrogen surpluses are comparable to the

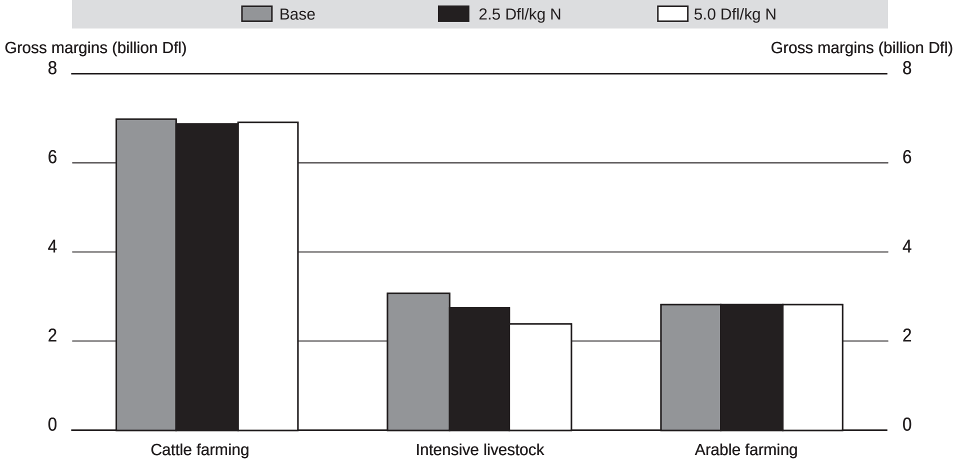
Table 8. **Income transfers from animal manure between sectors under different tax rates on nitrogen surpluses**

Million Dfl per year

Tax rate (Dfl per kg N surplus)	Cattle farming	Intensive livestock	Arable farming
0.0	–35	45	–10
2.5	310	–300	–10
5.0	617	–606	–11

Source: Own calculations.

Figure 4. **Gross margins in the cattle farming sector, the intensive livestock sector and the crop production or arable sector under different tax rates on nitrogen surpluses**
Billion Dfl



Source: Author.

developments under different tax rates on nitrogen from mineral fertilizers. Pigs and poultry numbers, however, would decrease gradually, while they would increase under a tax on nitrogen from mineral fertilizers.

With respect to land use (Table 10), acreage of potatoes may increase under a high levy on nitrogen surpluses.

Table 9. **Livestock composition under different tax rates on nitrogen surpluses**
Average numbers per year, mln

Tax rate (Dfl per kg N)	Dairy cows	Beef cattle	Meat calves	Finishing pigs	Sows	Poultry[1]
0.0	1.6	1.1	0.62	7.1	1.28	76.6
2.5	1.6	1.1	0.61	6.8	1.23	70.4
5.0	1.4	1.0	0.60	6.4	1.17	64.8

1. Excluding laying hens younger than 18 weeks.
Source: Own calculations.

Table 10. **Land use under different tax rates on nitrogen surpluses**

1 000 ha

Tax rate (Dfl per kg N)	Fodder crops			Arable land		Other
	Grass	Maize	Total	Cereals	Potatoes	
0.0	1 077	207	1 284	188	161	281
2.5	1 079	207	1 286	188	164	276
5.0	1 073	208	1 281	188	168	277

Source: Own calculations.

5. THE EFFECTS ON PRIMARY PRODUCTION

This paper investigates the effects of changes in agricultural taxes on the use of environmentally-harmful inputs, the gross margins from agriculture and environmental indicators in the Netherlands. The individual components of the nitrogen balance in the Netherlands are presented in Table 11.

A summary of the results is presented in Table 13. Using average data from 1990/91 – 1992/93 as the base period (Table 12), it can be seen that environmental taxes can decrease the use of environmentally relevant inputs.[4] However, it

Table 11. **The national nitrogen balance in the period 1990/91-1992/93**

Mln kg of N

Supply from animal manure	Use of mineral	Emissions of ammonia	Total supply of nitrogen nutrients (604 + 374 – 103)	Nitrogen uptake by crops	Trade/ processing	Nitrogen surplus (875 – 456 – 12)
604	374	103	875	456	12	407

Source: Own calculations.

Table 12. **Model results for base period 1990/91-1992/93**

Selected variables

Scenario	Tax (Dfl/kg N)	Mineral fertilizers (million kg N)	Feed concentrates (million kg)	Manure transport (million kg N)	Animal manure (million kg N)	Roughage prices (Dfl/kg dry matter)	N-surplus at soil level (million kg N)	Tax payments (million Dfl)	Gross margins (million Dfl)
Base	0	374	15 135	37.6	604	0.41	407	–	12.828

Source: Own calculations.

Table 13. **Effects of different tax rates on selected variables**

% difference with base period

Scenario	Tax (Dfl/kg N)	Mineral fertilizer concentrates	Feed transport	Manure	Animal prices	Roughage at soil	N-surplus payments	Tax margins (million Dfl)	Gross
N-feed con.	2.5	1.3	–8.6	–39.9	–5.1	–2.4	–4.2	1 090	–8.9
	5.0	2.0	–13.5	–59.3	–8.1	–3.9	–6.9	2 070	–17.1
N-min. fert.	2.5	–1.4	1.2	5.6	0.3	7.3	0	920	–7.2
	5.0	–18.1	1.8	–7.2	–10.3	19.5	–10.8	1 530	–13.9
Combination of inputs used	2.5	0.2	–7.4	–37.2	–4.6	5.6	–4.2	2 040	–16.2
	5.0	–4.7	–12.2	–60.4	–10.8	12.0	–9.1	3 900	–31.9
Nitrogen surplus	2.5	2.8	–3.7	–27.1	–2.0	–8.5	–0.7	356	–3
	5.0	–6.9	–7.6	–35.4	–11.9	–13.9	–11.3	469	–5.4

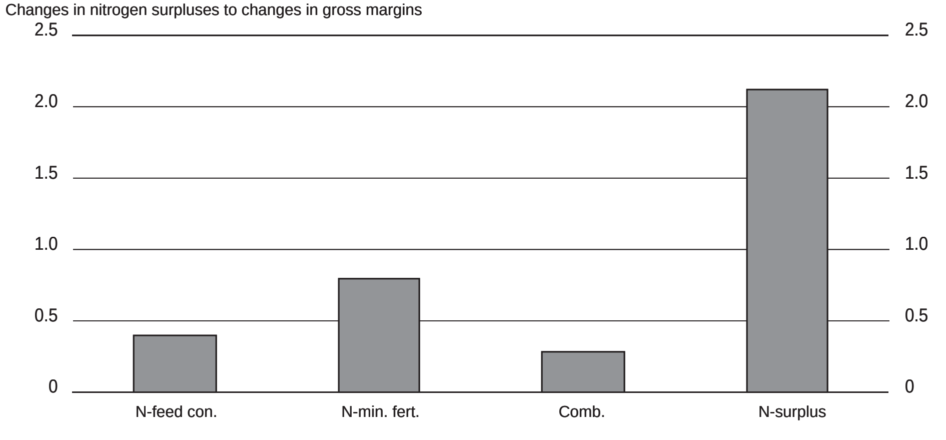
Source: Own calculations.

is also important to note that the relationship between the tax and environmental indicators or economic efficiency can vary significantly.

The economic efficiency of the policies can be calculated as the ratio of the change in nitrogen surplus at soil level to the changes in gross margins. The results are presented in Figure 5. In terms of economic efficiency, a tax on fertilizers is more favourable than a tax on nitrogen from feed concentrates. Following Dabbert *et al.* (1997), a tax on nitrogen in feed concentrates is likely to be relatively less efficient because there are more interfering variables as the causal chain between the nitrogen in the feed concentrates and the environmental indicator (damage) is longer. A combined tax on nitrogen in both feed concentrates and mineral fertilizers has a major impact on gross margins from agriculture, but with no additional improvements to the environment. Therefore, the economic efficiency of this type of tax system is very low.

The tax on nitrogen surpluses, including emissions of nitrogen as ammonia during application, would lead to a slightly larger reduction in nitrogen surpluses at soil level than a tax on nitrogen in mineral fertilizers. In addition, the effects on gross margins from agriculture are much less negative for the tax on nitogen surpluses, so the ratio of changes in nitrogen surplus at soil level to changes in gross margins favours such a tax.[5] Thus, it is likely that a tax on nitrogen surpluses is the most economically efficient tax for achieving reductions in nitrogen levels in agriculture in the Netherlands of the taxes presented here.

Figure 5. **Ratio of changes in nitrogen surpluses at soil level to changes in gross margins under a 5 Dfl per kg N tax rate**



Source: Author.

Further differences concern the costs of the policies, and their distribution among the various sectors involved. In the case of a tax on nitrogen from mineral fertilizers, the costs will be diverted primarily to the cattle farming and arable sectors, as well as the suppliers of nitrogen from mineral fertilizers. However, in the case of a tax on nitrogen surpluses, the costs would be diverted to the intensive livestock sector and, at a much lower rate, to the suppliers of nitrogen from mineral fertilizers. Furthermore, a tax on nitrogen surplus would probably stimulate the efficient use of nitrogen from animal manure in a more direct manner than a tax on nitrogen from mineral fertilizers would. A tax on nitrogen from mineral fertilizers would not charge farmers for the application of nitrogen from animal manure and so, whenever possible within the existing manure legislation, farmers might expand their manure production and application. In addition to the environmental risks at soil level from such actions, this would increase the emission of nitrogen as ammonia.

Another argument in favour of a tax on nitrogen surplus is given by Oude Lansink and Peerlings (1997). Using econometrically estimated arable farm models, they observed that a tax on nitrogen surplus would induce producers with a high nitrogen surplus to lower their surplus to a larger extent than producers with a small nitrogen surplus. Thus, such a tax will result in environmentally-favourable behavioural responses from those farms from which they are most desired. Therefore, they concluded that a tax on nitrogen surpluses is preferred to a tax on nitrogen from mineral fertilizers.

As far as the transaction costs involved, there may be an argument in favour of a tax on nitrogen from mineral fertilizers. The monitoring of nitrogen surplus at farm level for a nitrogen surplus tax might require substantial transaction costs compared to a tax on mineral fertilizers, providing the latter is chargeable at the level of producers or retailers of the fertilizers.

In addition to exogenous technical developments, other caveats should be noted for the model used in the present study:

– First, the model does not include the intensity effects per hectare or per head, or the corresponding yield functions. This might lead to an underestimation of the environmental effects and an overestimation of the economic effects of the taxation of environmental inputs. This shortcoming could be more or less captured through a discussion about the reliability of the results under different exogenous parameter values (*e.g.*, with alternative values for the efficiency of nitrogen from animal manure especially under a tax on nitrogen surpluses). A functional relationship would be preferable however.

– Second, market prices are considered to be exogenous. This means that the price elasticities of supply and demand for marketable inputs and outputs are assumed to be infinite. This applies, for example, if the domestic price is equal to the world market price and domestic developments do not influence the world market price. This is the so-called "small country assumption" (Oude Lansink and Peerlings, 1996). If price elasticities are somewhere between zero and infinity, however, then there will be scope for price changes due to changes in national demand or supply that result from the tax. For example, if the price elasticity of supply is between zero and infinity, the important changes in demand for feed concentrates under a high tax on nitrogen from feed concentrates could affect the market price of the feed concentrates. This is not included in the analysis because the elasticity is assumed to be infinite.

Other caveats should be noted about the assumptions used with respect to the uniformity of production possibilities and profit maximising behaviour over all farms (the aggregation bias) and the time dimension of the adjustments. Since DRAM is a comparative static model, the time-path towards completion of the adjustments is unknown.

Notwithstanding the shortcomings of the model, it is found that taxation of environmentally relevant inputs can be an effective measure to stimulate production practices in the Dutch agricultural sector that are less environmentally damaging, such as those which lead to a decreased use of purchased inputs like mineral fertilizers and feed concentrates.

6. IMPACT OF TAXES ON INCOME AND EMPLOYMENT IN THE AGRIBUSINESS

The impact of taxes in the agribusiness (primary production, food processing and deliveries) was assessed. A distinction was made between five different agribusiness complexes: arable, dairy, intensive livestock, field vegetables and flower bulb growers. Tables 14, 15 and 16 show the impact of taxes on gross value added and employment for the first three of these agricultural complexes.

A tax on feed concentrates would substantially affect the gross margins of the intensive livestock chain. Revenues from primary production would be reduced at a rate which is approximately double that of the total reduction in the intensive livestock farming chain. This would happen because the price of feed concentrates is considered to be constant and because the levies would be charged to primary production.

A levy on mineral fertilizers would mainly affect the arable and the dairy farming chains. The total impact of such levies on the agribusiness would be expected to be marginal because of the increase of production and employment in intensive livestock farming.

Table 14. **The impact of taxes on gross value added and employment of the arable complex**

1993

Sector	Base situation	Fertilizers	Feed concentrates	Both inputs	Nitrogen surplus
Primary sector, arable farming (gross value added, million Dfl)	946	–10.3	0.4	–8.1	–0.7
Food Processing	1 582	–0.2	2.1	1.6	0.7
Deliveries					
By food processing industries	48	1.0	1.7	2.6	0.1
By other industries and services	2 176	–0.7	2.2	1.1	0.2
Gross value added of arable chain	4 751	–2.4	1.8	–0.6	0.2
Primary sector, arable farming (employment, annual work unit)	16 575	0.6	3.6	2.1	–1.0
Food Processing	13 781	0.2	3.5	1.8	–0.8
Deliveries					
By food processing industries	396	2.3	3.1	3.5	–1.6
By other industries and services	26 126	–0.8	2.0	1.0	0.6
Employment in arable chain	56 878	–0.1	2.8	1.5	–0.2

Table 15. **The impact of taxes on gross value added and employment of the dairy chain**

1993

Sector	Base situation	Fertilizers	Feed concentrates	Both inputs	Nitrogen surplus
Primary sector, dairy farming (gross value added, million Dfl)	5 450	–11.2	–7.2	–16.7	–1.4
Food Processing	2 590	0.0	–0.4	–0.3	0.1
Deliveries					
By food processing industries	354	–0.1	–0.6	–0.6	0.1
By other industries and services	3 911	–0.1	–0.6	–0.6	0.1
Gross value added of dairy chain	12 305	–5.0	–3.6	–7.7	–0.6
Primary sector, dairy farming (employment, annual work unit)	83 563	0.0	–0.6	–0.5	0.1
Food Processing	26 492	0.0	–0.4	–0.3	0.1
Deliveries					
By food processing industries	3 057	–0.1	–0.6	–0.6	0.1
By other industries and services	2 127	–0.1	–0.6	–0.6	0.1
Employment in dairy chain	156 563	–0.0	–0.6	–0.5	0.1

Table 16. **The impact of taxes on gross value added and employment of the intensive livestock farming chain**

1993

Sector	Base situation	Fertilizers	Feed concentrates	Both inputs	Nitrogen surplus
Primary sector, intensive livestock farming (gross value added, million Dfl)	982	0.7	–24.7	–24.0	–11.0
Food Processing	1 364	1.8	–12.4	–10.7	–5.2
Deliveries					
By food processing industries	1 136	1.6	–11.5	–9.9	–5.0
By other industries and services	3 642	1.6	–11.4	–9.8	–5.0
Gross value added of intensive livestock farming chain	7 125	1.5	–13.4	–12.0	–5.9
Primary sector, intensive livestock farming (employment, annual work unit)	19 580	1.6	–11.9	–10.3	–5.2
Food Processing	16 778	1.8	–12.6	–10.9	–5.3
Deliveries					
By food processing industries	9 846	1.6	–11.5	–9.9	–5.0
By other industries and services	38 209	1.6	–11.4	–9.8	–5.0
Employment in intensive livestock farming chain	84 413	1.6	–11.7	–10.2	–5.1

A levy on nitrogen surplus would mainly affect the intensive livestock farming chain, although income losses in primary production would be larger than income losses in the total chain. Employment effects would mainly arise in the intensive livestock chain.

7. ADJUSTMENT OF VAT RATES ACCORDING TO PRODUCTION METHODS

In addition to the instruments discussed in the previous sections (*e.g.*, taxes on inputs used or on emissions produced), other instruments for the achievement of more sustainable production methods should also be considered. In the following, the role of the tax system for such purposes will be explored. Emphasis will be given in particular to an evaluation of the Value Added Tax (VAT) system. The potential to use VAT to differentiate according to the production methods applied will be examined. Thus, an evaluation of the possibility of adjusting VAT levels for meat products, according to the production method used, will be presented. In that case, a lower VAT rate would apply to meat produced with sustainable production methods compared with meat produced by other production methods. Such differentiation might compensate, for example, for higher production costs of the production methods which meet certain sustainability criteria. Theoretically, this might stimulate more sustainable production methods.

There are two levels of VAT which presently apply in the Netherlands, 17.5 per cent and 6 per cent, with the low rate generally applying for all consumables (except alcoholic beverages) and flower products. Generally speaking, two options would be possible to differentiate the VAT rate according to the agricultural production methods applied:

- The application of a 0 per cent VAT rate to meat produced according to certain sustainability criteria. This option would slightly reduce the price of such meat, although it may only stimulate ecological products to a limited extent since price differences between ecological products and traditional products are normally at least 10-20 per cent.

- Raise the VAT rates of common production methods to the higher VAT rate (17.5 per cent) and maintain ecological meat at the lower level of 6 per cent. Revenues generated by this increase in VAT rates could be returned to consumers by a lowering of income taxes. Alternatively, this may increase inflation as the consumption of meat is a substantial share of total consumption. Food products make about about 15% of total private consumption, with approximately a quarter of this for meat and meat products. Such an increase in the tax rates would increase inflation by some 0.4 per cent if a substantial share of the meat purchased is taxed at the higher VAT rate. This could be compensated by changes in income taxe rates. Administrative costs, however, might be high if it is necessary to ensure the compensation does not have any regressive distributional effects.

Other issues also need to be considered when proposing changes to the VAT system in the Netherlands. First, altering the VAT system is now part of European directives. It is intended that a harmonisation of VAT rates will be achieved in the context of the European Union. Also, the current directive on VAT rates would not allow the introduction of the zero rate for more products. The application of VAT rates which differentiate between products according to production methods might also be hampered for the following reasons:

- It is difficult to apply a strict definition of sustainable production methods, as compared with traditional production methods. Sustainable production of meat could not be defined in a unique manner and it would be likely to require a graduated scale. One option would be to apply the Council Regulations of the European Union regarding organic agriculture and livestock production methods.

– It would be difficult to apply a VAT system which differentiates according to production methods to products which are composed of combinations of meat and meat products. This would apply particularly for products which are only partly composed of meat, often originating from diverse sources (*e.g.*, pizzas).
– Sustainable production methods could not be defined only for primary production, but would also be required for the processing and transport processes. Harmonisation of the VAT rates according to the production methods applied would, therefore, imply that the import of meat to the Netherlands which originates from other EU Member States would also need to be part of the same regime. One might, however, doubt the sustainability of meat which is transported over such long distances.

Given the requirements for devising a system to differentiate VAT rates according to production methods, it would most likely require the labelling of meat according to the ecological criteria it meets. The overall impact of such a system on the achievement of sustainable production methods might be limited, and more effective instruments may be available to achieve such goals.

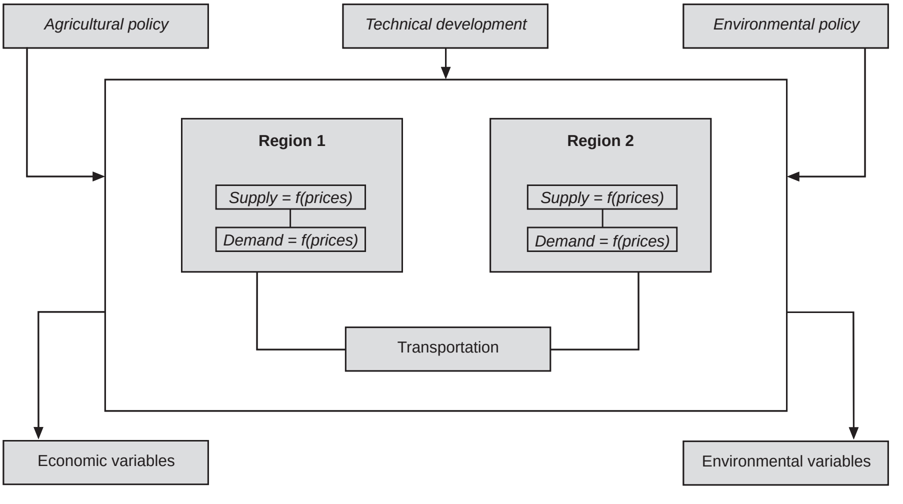
VAT rates on fertilizers and pesticides in the Netherlands are currently at 6 per cent, a substantially lower rate than those applied in most of the neighbouring countries. An increase in the VAT on mineral fertilizers may stimulate more sustainable production methods which are less dependent on such inputs.

Annex

Because of their ability to investigate the economic effects of isolated changes on particular parameters, economic models have been used extensively in the evaluation of alternative agricultural policies. The Dutch Regionalised Agricultural Model (DRAM) can be characterized as a price-endogenous, spatial equilibrium market model (Takayama and Judge, 1971). A schematic presentation of the model is presented in Figure A1. The model includes endogenous economic and environmental variables. Agricultural policies, technical development and environmental policies are considered exogenous variables. The base period used for the exogenous variables in the model is the average of the period 1990/91-1992/93.

The model is built around a set of linear regional demand and supply functions describing the most important regional input and output markets of the Dutch agricultural sector. The model distinguishes fourteen regions. Seven regions have clayey soil, five regions have

Figure A1. **Schematic representation of DRAM**



Source: Author.

sandy soil and two regions have peaty soil. Each region is treated like a large, more or less mixed farm.

The model's objective function maximises the national profit from agriculture under the restriction that demand equals supply in every regional market. First order conditions for an optimal solution imply that marginal revenues equal marginal costs of production. It is assumed that interactions between regions result from the profit maximising behaviour of the producers through taking advantage of regional price differences (Takayama and Judge,1971; Labys, 1989). Profits are defined as the total gross margin from agriculture.

Commodity balances are included which require regional markets to clear. We assume a perfectly inelastic supply of purchased inputs. Intermediate balances, including manure and mineral (nitrogen and phosphorous) balances, equate regional production, international trade and interregional imports and exports with regional demand for the intermediates. The (shadow)prices for land and quotas are derived from restrictions on the regional availability.

The assumptions that are made about the production functions used in the model are important. Production technologies are specified as constant proportional (Leontief) production functions. However, a complex linearised system of alternative production methods to produce milk is included in the dairy farming sector.

The environmental indicators taken into account are the emission of nitrogen as ammonia from the stable, the pasturing and application of manure, mineral surpluses at soil level and the use of pesticides.[6] The mineral surpluses in the soil at the regional level are calculated as the supply of minerals from animal manure and inorganic fertilizers, plus the net interregional and international trade of minerals, minus the uptake by crops and the emission of nitrogen as ammonia.

The model used in this paper is slightly different from Helming (1996, 1997). The model presented here assumes exogenous output prices and increasing marginal costs per unit of crop and intensive livestock production. These are derived from quadratic cost functions. The parameters of these functions are calculated from exogenous prices of purchased inputs per unit of production (except prices of fertilisation) and shadow values on actual land use and livestock numbers. The shadow values are obtained from an initial model run with the areas and livestock numbers restricted to actual figures. This approach is called Positive Mathematical Programming (PMP) and calibrates the model exactly to the actual figures without any loss of flexibility. More detailed information on PMP is given by Howitt (1995) and Horner *et al.* (1992).

Notes

1. The effects of the tax rate on gross margins from arable farming is not included in the figure. Model results show that there is a small but positive relationship between the tax on nitrogen in feed concentrates and the gross margins from arable farming.
2. This is certainly not a precise indicator of the welfare effects, because it does not take into account the impacts on the rest of the economy or any positive effects from the tax revenues generated.
3. This is an overestimation of the impacts on gross margins in the intensive livestock sector because we assume that all the land is owned by the cattle farming sector and the arable sector.
4. The choice of the base period is important. Under different market price relationships, for example between prices of nitrogen from mineral fertilizers and feed concentrates, effects could be rather different.
5. Results are comparable in case no levy-free zone is considered.
6. The possible effects of a tax on the use of pesticides is solely based on changes in land use.

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Effective Tax Rates on the Marginal Costs of Different Modes of Freight Transport

A *Case-Study Approach on* Road, Rail, Air *and* Inland *Shipping in* Switzerland, The Netherlands, *Germany and* France

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1. INTRODUCTION

1.1. Purpose, scope and methodology

This study examines how taxes on various inputs (labour, capital equipment and fuels) as well as user charges (tolls, airport charges) together affect the relative marginal costs of various modes of freight transport (road, rail, air and inland shipping),[2] and as a consequence how they influence the modal split through changing the relative prices of transport services. The study analyses these effects in four countries: Germany, France, the Netherlands and Switzerland.

In addition, the study serves as an exploration of the practicability of using the ratio of charges and taxes over marginal cost as a measure of distortions due to government taxation and charging policies. Currently, there is no easily identifiable measure of support to transport, partly because most of this support is embedded in government provision of infrastructure and transport-related services, and partly because it is tax differentials between modes and fuel types that effectively supports different transport modes or alternatives relative to each other and in comparison to their counterparts in other countries.

The starting point of the analysis is that if taxation and charges influence the choice between modes of freight transport, they will do so by influencing the relative marginal costs of *competing* freight transport services. It was therefore essential to calculate these effects on hauls for which all reviewed modes of transport were likely to compete. Therefore, the calculations were based on a standard haul of 40 tons (28 tons for Switzerland) over a distance of 500 km. For road freight, the figures for this standardised haul were based on actually measured costs. For the other modes of transport, these figures were arrived at using annual operating costs.[3]

The study draws heavily on the analysis developed by McKenzie, Mintz and Scharf (1992) for quantifying differential taxation of Canadian and US passenger transportation. In essence, this methodology consists of estimating the total pecuniary effect of taxes, subsidies (and charges) as a percentage of the marginal costs (exclusive of taxes, subsidies and charges). Using a Cobb-Douglas function, a simple formula is derived that expresses the overall *effective tax rate on the marginal cost of production* in terms of two basic parameters: *the relative shares of the analysed inputs* (labour, capital, fuels and infra-structure services) *in marginal costs and the marginal effective rates of taxation and charges on the various inputs* (for this study, the amount of taxes and charges for the standardised "marginal" haul of 40 t/500 km). Ideally, a marginal effective tax rate analysis would take into account the fact that a tax on an input will generally be split between the producers and consumers of the input, dependent on the price elasticities of demand and supply for that input. Because of data unavailability, the present calculations are based on the (false) assumption that the full tax is borne entirely by the providers of the transport services.[4]

The level and type of government provision of transport infrastructure and related services for the different modes of transport has a strong effect on the relative competitiveness of the various modes. Its effect on relative marginal costs may very well significantly exceed those of taxes and charges. Since taxes on freight transport contribute to government revenues out of which the expenditures for infrastructure and services are paid, there may be a link between the taxes paid and the level of (marginal cost decreasing) infrastructure provision. To put it differently, high taxes, if linked to a higher level of infrastructure and transport-related service provision, may not adversely affect the relative competitiveness of the various modes of freight transport. While the transport operators may have to pay higher taxes, they will also have access to better infrastructure and transport services, which may reduce their time-related or other costs. In this study, an attempt was made to express the difference between the transport related taxes paid on the one hand, and government expenditures on transport infrastructure and services on the other (the transfers). When complemented with estimates of the effects of infrastructure provision on the relative marginal costs of the different modes of freight transport, this could help to answer the question of to what extent the transfers alter the relative competitiveness of the various modes of freight transport. Unfortunately, this study was not able to examine the effects of infrastructure and related services provision on marginal transport supply costs. So, for the time being, estimates of the effect of transfers on marginal costs (ignoring the effects of infrastructure provision) have been carried out for road (CH, D, F and NL) and rail (CH and F).

1.2. A preliminary study

This study is of an exploratory nature. Much work remains to be done in terms of gathering and refining data (which do appear to be available, at least in principle). However, due to the current data limitations, the results should be interpreted with care. Moreover, some obvious extensions of the analysis have not yet been pursued. For example, the separate effects of tax rates and charges on marginal costs were not calculated, nor was the effect on relative marginal costs of a rise in fuel taxes combined with lower tax rates on labour. Nor does the study address fundamental *political* questions, such as whether charges should be considered as taxes or payments for services,[5] or whether the differences that were found between government policies on the relative marginal costs of the various modes of transport (sufficiently) reflect political preferences for certain modes of transport over others.

1.3. Structure of the Report

Chapter 2 describes the methodology used in the study and Chapter 3 presents the results in more detail. The annex contains the main statistical data, a description of the scenarios that were used in the model on which the standardisation of road haulage is based, and an overview of the statistical sources.

2. METHODOLOGY AND PARAMETERISATION

2.1. The estimation of effective tax rates on the marginal costs of production

The estimation of effective tax rates on the marginal costs of production,[6] as applied in this study, is aimed at estimating the effect of taxes and payments for infrastructure services minus subsidies on the marginal costs of various modes of freight transport and, as a result, the effects of these payments on the relative competitiveness of the different modes of transport. There are several important remarks to be made on this exercise:

- *All taxes that bear on transport have been included in this study, although these tax rates are not always specific to the transport sector, such as taxes on labour, and so are not always subject to transport policies.*
- *Moreover, for simplicity reasons, all charges for infrastructure and transport services use (tolls, airport charges, etc.) are treated in the same way as taxes because they are often strongly influenced by government policies. Ideally, one should make a distinction between the tax element in these charges and the portion that should be considered as pure payment for the infrastructure and services provided.*
- *The analysis in this study does not take into consideration the fact that a tax on an input is generally split between the producer and the user of this input, according to the price elasticities of demand and supply of the input. For simplicity reasons, and because of a lack of data, it is assumed that the tax is fully paid by the user of the input, which is not far from the truth as the demand for inputs is often inelastic in transport, while their supply is generally elastic.*

In order to determine to what degree taxes and charges influence marginal costs, several steps must be taken.

1. The actually paid taxes and charges on the various inputs must be calculated.
2. The taxes and charges paid by the various transport services must be estimated as a proportion of the total marginal costs (without taxes and charges) of these services, for which it is necessary to:
   – *standardise the haulage to a* 40 *ton*, 500 *kilometre haul*;
   – *estimate the relative input shares of the various inputs*; *and*
   – *calculate the marginal effective tax rates on each of these inputs*.

In the following section, these steps are briefly summarised.

2.1.1. *Calculating taxes and charges*

In principle, all taxes and charges that bear on the transport sector are taken into account. Labour and some capital taxes are not specific for the transport sector, although there may be some rates which apply only to the transport sector. Attempts were made to investigate such special rates. The main taxes considered include vehicle taxes, fuel excise duties and other energy taxes and user charges (tolls, airport charges). Since these tax rates are related to different tax bases, they had to be transformed into *ad valorem* rates, in order to be applicable to the standardised haul. For road, they were first corrected for exemptions and reductions, then expressed as tax rates on the fuel prices exclusive of taxes, and finally were imputed on an actual paid taxes. This formed the basis for the standardised haul.

These taxes are imputed on a share/year basis, with the reference year 1996, except for road. For road freight, tax rates have been based on actual costs (as derived in *Service d'étude des transports*, Swiss Federal Department for Energy and Transport by Ecosys®, 1998, and applied in the *Excel Workbook "Scénarios européens de routage"*, developed by Ecosys®, reference year 1997).

The labour taxes used are those applied to the mean taxable personal income, exclusive of social security premiums. They include some "educated guesses" because of the unavailability of standardised, national data. Capital taxes include those on capital assets,[7] taking fiscal depreciation rules (Capital Cost Allowances, CCA) into account. They are based on mean values with respect to the transportation sector.

2.1.2. *Effective tax rate on marginal cost*

Assuming a Cobb-Douglas production function, with inputs of labour (L), capital (K), and fuel and usage services (G), and according to McKenzie, Mintz and

Scharf (1992), the following expression for the effective tax rate on marginal costs (T) has been derived for a given mode of transport (road, rail, air, inland shipping):

$$T = (1 + t_L)^{\alpha_L} \times (1 + t_K)^{\alpha_K} \times (1 + t_G)^{\alpha_G} - 1$$

in which t is the "marginal" effective tax rate on the relevant input.[8] The α_L, α_K and α_G, are the shares of the various inputs – labour (L), capital (K) and fuels/electricity and charges (G) – in the total cost. Their sum is equal to 1. This equation makes it possible to estimate the effective tax rate on marginal costs, using only two parameters: the marginal effective tax rate on each input (t) and the share of each input in the marginal costs (α).

Defining the standard haul

Since we want to analyse the potential impacts of the taxation and charges regime on the competitiveness of the various modes of transport, we must relate the effective tax rates on marginal costs (T) to a haul for which these modes of transport may actually compete. It was assumed that such a haul could be 40 tonnes (28 t for Switzerland) over 500 kilometres.

This hypothetical haul was derived from scenarios of real hauls by road for the separate countries, for example Basel (CH) – Bellinzona (CH) (247 km), Paris (F) – Mt-Blanc (Italian border) (630 km), and Dutch border – Swiss border (545.5 km). The scenarios that are used to calculate the costs are given in the annex.

The haul by train is based on a scenario of a 50 ton load over nearly 1 000 kilometres, for example from Geneva to Rotterdam. Taxes on energy are actually paid taxes calculated on a share/year basis.

The standard haul for air was derived from a 50 t 500 km freight transport basis as far as possible. Taxes on energy and airport and other taxes are actually paid taxes calculated on a share/year basis. IATA mean values (operating cost per air tonne kilometre, ATK) have been used when specific data were not available. For the Netherlands, the air freight data apply for Northern Europe.

The inland shipping standard haul is based on a 50 t 500 km freight transport. Net effective tax rates for inland shipping in France have been calculated.

Estimating input shares (α)

Once the standard haul has been derived for each mode of freight transport, the estimation of the relative input shares is rather straightforward. All costs, however, must be attributed to one of the selected inputs [labour (L), capital (K) and fuels/electricity and user charges (G)]. The input shares for road have been derived from the available data on actual hauls; those for rail, air and inland shipping have been derived from yearly operating cost data. As a result, the latter are less precise.

Estimating the marginal effective tax rates on inputs (t)

Estimating the marginal effective tax rates on the various inputs (t) requires the calculation of the tax wedge between the input costs with and without taxes and charges for the standard haul, and relating this wedge to the input costs without the taxes and charges. This implies transforming the *statutory tax rates* on labour, capital, fuels and charges for infrastructure services into the "*haul rates*" of these taxes and charges on the actual amount of the inputs required to perform the standard haul. These "haul rates" constitute the "*marginal*" *effective ad valorem tax rates* for each input, which are combined together in the Cobb-Douglas function to estimate the effective tax rate on marginal cost. To arrive at the figures used in this analysis for the separate countries, only their rates have been imputed, assuming that the haul would be performed entirely within one country. A road haul through France will often require the payment of tolls over certain distances. For the purpose of this study, these road tolls have been calculated based on the average cost per km on toll roads for half the haul and off toll roads for the other 250 km.

2.1.3. *Accounting for transfers*

Expenditures by government on infrastructure and transport-related services tend to decrease the marginal costs of transport for the freight transport companies. Their effect on the relative marginal costs may very well more than compensate for the effects of transport-related taxes and charges. Since taxes on freight transport contribute to government revenues out of which the expenditures for infrastructure and services are paid, there may be a link between the taxes paid and the level of (marginal cost decreasing) infrastructure that is provided. This study does not look into the effects of infrastructure and service provision on marginal costs, but does express the difference between the transport-related taxes paid and actual government expenditures on infrastructure services (transfers).

In all the countries analysed, there is a discrepancy between the revenues collected from road and rail freight users and the expenditures (current account) spent on road and rail infrastructure and services. For road, these transfers are calculated in "Distortions d'ordre fiscal et financier dans le transport des marchandises: Cas du transport routier lourd – France, Suisse, Allemagne, Pays-Bas", (CEMT/OECD, 1998). The total expenditures on road infrastructure are split between freight and passenger traffic in national road accounts. In Switzerland, the revenues of road related taxes exceed the current expenditures for infrastructure by almost 10 per cent. In France, they are almost equal. In Germany, the revenues exceed the current expenditures by only a few percentage points (less than 5), but the difference is particularly significant in the Netherlands where revenues exceed expenditures by about 120 per cent).

It was not possible to apply the same methodology for rail in this study. Indeed, rail infrastructure is generally paid through public accounts, with no distinction between the portion spent for freight and that for passenger traffic. Accordingly, transfers are 100 per cent in Switzerland and 70 per cent in France. Rail in other countries has not yet been investigated.

Estimates of the effects of transfers on marginal costs (not including the effects of infrastructure provision) have been carried out for road (Switzerland, Germany, France and the Netherlands) and rail (Switzerland and France). They enter the estimations of the effective tax rates on marginal cost as deductions or additions to taxes on capital. The formula for the effective tax rate on marginal cost (T) for each mode of transport then becomes:

$$T = (1 + t_L)^{\alpha_L} \times [1 + t_K \times (1 \pm \tau_K)]^{\alpha_K} \times (1 + t_G)^{\alpha_G} - 1$$

in which $(1 \pm \tau_K)$ equates general revenues from freight transport related taxes to the expenditures on infrastructure. Or, to put it differently, applying τ_K makes the marginal effective tax rate on capital equal to the rate that would result if the government expenditures were equal to the taxes actually paid. Ideally, both the marginal tax rate and the marginal tax rate on fuels would be corrected. For simplicity, we have corrected the marginal rate on capital for the full amount. This leads to an overestimation of the effect, since the share of taxes on capital generally exceeds the share of taxes on fuels and charges for infrastructure use. If the contribution to general revenues exceeds the expenditures, the marginal effective tax rate on capital must be reduced (*i.e.*, τ_K has a minus sign).

3. RESULTS

3.1. Values for the parameters that determine the effective tax rate on marginal cost

The procedure described above leads to the values for the parameters as shown in Table 3.1. It appears that these values differ considerably across countries for each mode of transport, and within each country across the different modes.

Some caution is in order. Some of the parameters are based on in-depth analyses while others are derived from more general statistics and refer to mean values. Typically, *ad valorem* fuel taxes (from the scenarios) and input share structures (operating costs) correspond to the first category, while labour taxes include "educated guesses". Capital taxes include mean values with respect to the transportation sector. The sources used to obtain these numbers are given in the statistical annex.

Table 3.1. **Marginal effective tax rates and input shares of a 40 ton, 500 kilometre haul by various modes of transport**

Rounded figures

Transport mode	Country	"Marginal" effective tax rates (t)			Input shares (α)		
		Labour	Capital	Fuel/ Charges	Labour	Capital	Fuel/ Charges
Road	Germany	0.26	0.14	1.51	0.51	0.42	0.07
	France	0.16	0.12	3.07	0.51	0.43	0.06
	Netherlands	0.12	0.15	1.48	0.46	0.46	0.09
	Switzerland (28 t)	0.15	0.16	2.24	0.54	0.40	0.05
Rail	Germany	0.26	0.08	0.10	0.55	0.41	0.04
	France	0.16	0.12	0.85	0.62	0.35	0.03
	Netherlands	0.12	n a	n a	n a	n a	n a
	Switzerland	0.15	0.13	0.05	0.46	0.38	0.16
Air[1]	Germany	0.30	0.15	1.18	0.38	0.51	0.12
	France	0.19	0.14	0.30	0.25	0.68	0.07
	Netherlands	0.14	0.14	0.85	0.21	0.65	0.14
	Switzerland	0.18	0.14	0.94	0.30	0.59	0.11
Inland shipping	France	0.11	0.05	0.85	0.71	0.26	0.03

1. The marginal effective tax rates on marginal cost for air are rather strongly influenced by airport (user) charges. According to IATA they vary between US$ 0.039 and US$ 0.617. In this study the lower value of US$ 0.039 is used.

Source: Own calculations.

The German tax rates on labour are especially high, varying between 0.30 (for aviation) and 0.26 (for road and rail). It should be noted, however, that social security premiums are not included.

In general, the effective *ad valorem* tax rates on fuel are high, particularly for road. The fuel rates for air are also significant (somewhere between those for road and rail), mainly because of airport charges.

The input shares also show considerable variation, notably in fuels for rail and labour and fuels for air. The "marginal" effective *ad valorem* tax rates on fuels are very high compared with the rates on capital and labour. Comparing, Tables 3.1 and 3.2 (and see also Figure 3.1), however, reveals that due to the relatively small share of fuels in the marginal costs, *the contribution of the marginal effective tax rates on fuels, including charges for the use of infrastructure, to the effective tax rate on marginal costs is very close to the effect of taxation on the other inputs.*

Table 3.2. **Effective tax rates on marginal cost**

Transport mode	Country	Contribution to the effective rate on marginal cost			Effective Tax Rate on Marginal Cost (in %) T^i
		Labour	Capital	Fuel charges	
Road	Germany	1.13	1.06	1.07	26.8
	France	1.08	1.05	1.08	22.6
	Netherlands	1.05	1.06	1.08	21.3
	Switzerland	1.08	1.06	1.06	21.6
Rail	Germany	1.14	1.03	1.00	17.9
	France	1.10	1.04	1.02	16.1
	Netherlands	n a	n a	n a	n a
	Switzerland	1.07	1.05	1.01	12.3
Air	Germany	1.10	1.07	1.10	29.7
	France	1.04	1.09	1.02	16.2
	Netherlands	1.03	1.03	1.09	22.0
	Switzerland	1.05	1.05	1.07	21.8
Inland shipping	France	1.08	1.01	1.02	11.1

Source: Own calculations.

3.2. The effective tax rates on marginal costs (T_j)

It should be recalled that the effective rate of taxation on marginal costs (T) is derived from the equation:

$$T = \prod_j (1 + t_j)^{\alpha_j} - 1,$$

in which t is the marginal effective tax rate on the various inputs, α is the share of the relevant input in the total cost of the standard haul and the subscript j denotes labour, capital and fuels, electricity and charges. In Table 3.2 the computation of the effective rate of taxation on marginal cost is given, including showing the values for the different factors such that:

$$Contr. = (1 + t_j)^{\alpha_j}$$

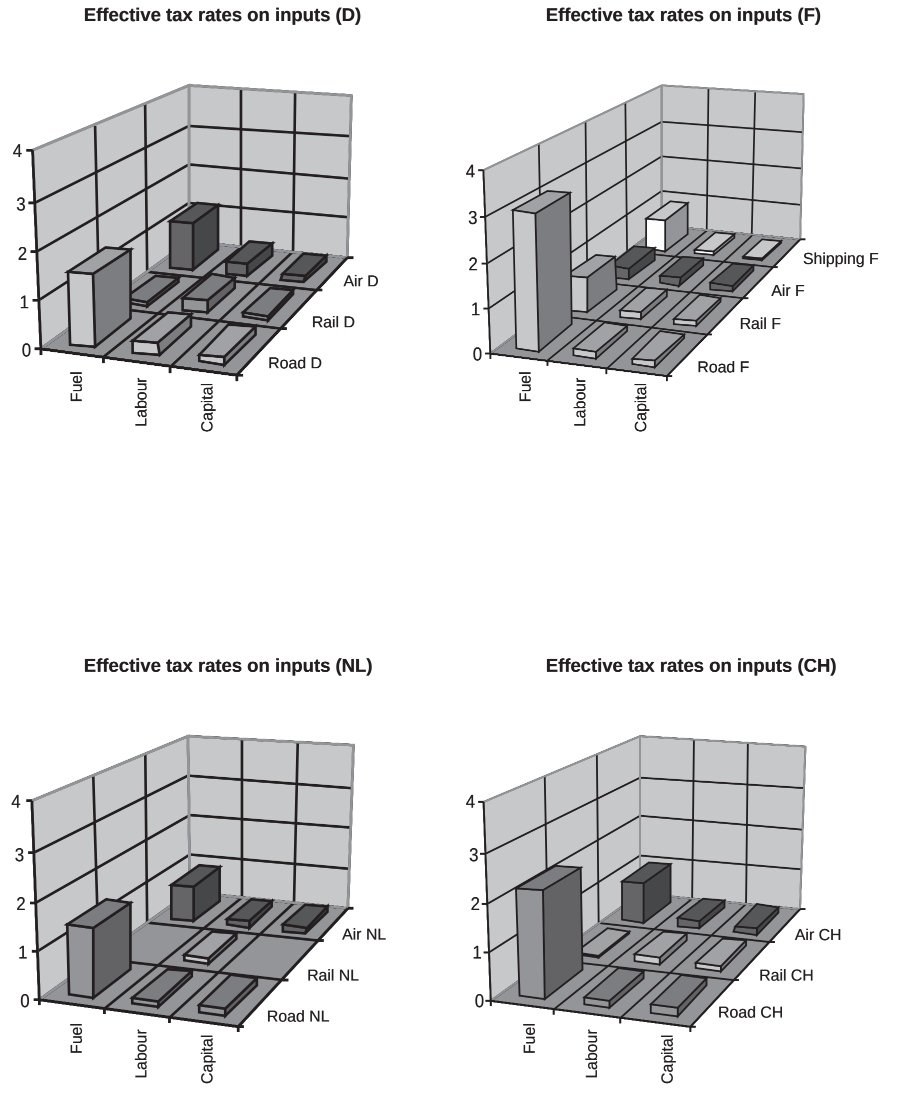
is the contribution to the effective tax rate on marginal cost of the various inputs.

This is shown in graphical form below (Figure 3.2).

Large differences were found in the effective tax rates on marginal costs between the neighbouring countries for all modes of transport and between the different modes of transport within each country.

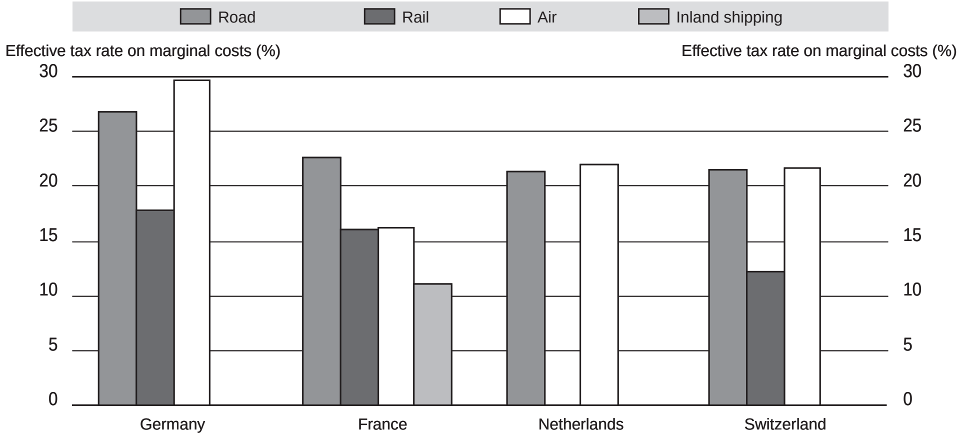
Rail freight was found invariably to be taxed lightly and road freight relatively heavily. The effective tax rate on the marginal costs of production for air freight was found to be of the same order as road freight (with the exception of France). Although the tax rates on aviation fuel are lower than on road fuel, the larger share

Figure 3.1. **Effective tax rates on inputs for different modes of transport for Germany (D), France (F), the Netherlands (NL) and Switzerland (CH)**



Source: Author.

Figure 3.2. **Effective tax rates on marginal costs**



Source: Author.

of fuel in producing a standard haul of air freight, together with high airport (user) charges, results in an effect of fuel taxes on the effective tax rate on marginal costs for aviation that is very close to that for road transport (except for France). Since charges are more common for air transport than for road, if the effects of taxation alone were taken into account these figures would presumably be considerably lower than for road freight (even in the absence of road tolls).

The relatively high effective tax rates on the marginal costs of production for German road and rail freight compared to other countries is, to a large extent, explained by the relatively high rates of taxation on labour there (for all modes of transport), which happens to take a larger share in the cost structure of road and rail transport. The relatively high effective tax rate on the marginal costs of production for German air freight is strongly influenced by the combination of relatively high rates of taxation on labour and high fuel taxes. In total, the German taxation regime, like all the other taxation regimes examined (to the extent that data was available), seems to favour rail strongly over road and air freight.

The high relative effective tax rate on the marginal costs of production for French road freight compared to other countries is primarily the result of tolls. The low marginal effective tax rate on air freight is explained by relatively low rates on fuel. The French taxation regime thus favours rail, air and inland shipping over road freight.

The Dutch taxation regime seems to be neutral between air and road freight, but it levies less taxes on road than Germany and France, mainly because of lower labour taxes than Germany and the absence of road tolls, which are common in France.

The Swiss system seems to be comparable with the Dutch regarding the overall marginal effective tax rates and the absence of discrimination between road and air freight, despite significantly higher tariffs on fuel and payments for infrastructure in Switzerland, and a scenario based on 28 ton hauls.

3.3. Allowing for transfers

Transfers are defined as the difference between the specific taxes on road, rail, air or inland shipping (such as taxes and charges on fuel or electricity; on vehicles, and for the use of infrastructure, like tolls, airport and harbour charges) and government infrastructure and transport service expenditures for the modes of transport under examination. Transfers can have a positive or a negative sign. Since our starting point is the actually paid taxes, allowing for these transfers would lead to lower marginal effective tax rates if the taxes and charges exceed government infrastructure expenditures, and would lead to higher marginal effective tax rates if taxes and charges do not cover government infrastructure expenditures. Government infrastructure expenditures can be calculated on the basis of capital expenditures or on the basis of current expenditures. The latter have been used in these calculations. The correction factor is labelled and solves the following equation:

$$t_K^E = (1 + \tau) \times t_K,$$

in which the superscript E denotes the marginal effective tax rate, presuming this rate is set at such a level that the tax revenues on “fuel” are equal to government expenditures on infrastructure services. The results are given in Table 3.3.

For road transport, it is only in the Netherlands that the net transfers (from the transport sector to general revenues) appear to have a noticeable effect on the overall marginal effective tax rates. If the Dutch road freight sector were paying only for road infrastructure expenditures through their road-related taxes and charges, the overall effective tax rate on the marginal costs of production for road freight would increase by 4 percentage points to 21.3 per cent.

For rail, the differences for both the analysed cases (France and Switzerland) are significant. If the marginal effective tax rates reflected government expenditures on rail infrastructure, the effective tax rates on marginal costs would rise by approximately 4 percentage points for both.

Table 3.3. **Effective tax rates on marginal costs, adjusted for transfers**

Transport Mode	Country	Marginal effective tax rate			Effective tax rate on marginal cost (%) (pre-adjustment values in brackets)
		Labour	Capital (t^E)	Fuel charges	
Road	Germany	0.26	0.13	1.51	26.5 (26.8)
	France	0.16	0.12	3.07	22.7 (22.6)
	Netherlands	0.12	0.06	1.48	17.3 (21.3)
	Switzerland	0.15	0.18	2.24	22.3 (21.6)
Rail	France	0.16	0.20	0.85	19.0 (16.1)
	Switzerland	0.15	0.25	0.05	16.8 (12.3)

Source: Own calculations.

4. CONCLUSIONS

1. Given the relatively small share of fuel in the costs of the standardised 40 ton 500 km haul, relative marginal costs are only moderately sensitive to fuel taxes. Tolls and air-related user charges, however, seem to contribute significantly to differences in total marginal effective tax rates.
2. It is particularly labour taxes and charges for infrastructure that seem to have a strong impact on the overall effective tax rates on the marginal costs of production and are among the largest single causes for discrimination between the modes of transport within any one country and for differences between countries for any single mode of transport.
3. Since the differences in overall marginal effective tax rates on the various modes of freight transport have probably been in place for a long time, it seems that what effect they have on the relative prices (marginal costs) of different transport modes has had a rather limited effect on the modal split. This would support the thesis that the competitiveness of the various modes of transport is mainly determined by qualitative factors, like speed and punctuality, and thus is primarily a result of the quality and availability of infrastructure.
4. In spite of the fact that, at present, insufficient data is available for a *precise* calculation of the marginal effective tax rates on competing segments of the transport market, this study seems to indicate that estimating the effective tax rates on marginal costs may be a practicable tool for analysing whether taxes, subsidies and infrastructure charges on the relative prices discriminate between various transport modes, and between the same modes in different countries.
5. It also seems feasible to construct an indicator of the effects of net transfers (from the transport sectors to general revenues) on the relative marginal costs for the various transport modes.

Statistical Annex

Including taxes, charges and infrastructure expenditures

Table A1. **Labour taxes**

Country	Mode	Tax Rate	Source
Germany	Road	0.259	Compared Law; Dossier Lefebvre (low)
	Rail	0.259	Compared Law; Dossier Lefebvre (low)
	Air	0.297	Compared Law; Dossier Lefebvre (mean)
France	Road	0.158	Compared Law; Dossier Lefebvre (low)
	Rail	0.158	Compared Law; Dossier Lefebvre (low)
	Air	0.188	Compared Law; Dossier Lefebvre (mean)
	Shipping	0.11	Compared Law; Dossier Lefebvre (lower)
Netherlands	Road	0.1225	Dutch NEA
	Rail	0.125	Dutch NEA
	Air	0.1425	Dutch NEA, adapted
Switzerland	Road	0.1475	Geneva Fiscal Law
	Rail	0.1475	Geneva Fiscal Law
	Air	0.1775	Geneva Fiscal Law

Table A2. **Capital taxes**

Country	Mode	Tax Rate	Source
Germany	Road	0.14	AfA Tabellen
	Rail	0.0844	D Bahn
	Air	0.15	Lufthansa
France	Road	0.12	CNR (1996)
	Rail	0.118	SNCF
	Air	0.14	Air France
	Shipping	0.047	French Survey
Netherlands	Road	0.146	Dutch NEA
	Rail	–	–
	Air	0.14	IATA London, mean value
Switzerland	Road	0.1616	Swiss ASTAG
	Rail	0.125	CFF SBB
	Air	0.14	IATA London, mean value

Table A3. **Fuel taxes**[1]
(for road: net *ad valorem* vehicle taxes + fuel excise duties + user charges)

Country	Mode	Tax Rate	Source
Germany	Road	1.5107	Scenarios developed by Ecosys® 40 t 500 km
	Rail	0.1	Taxes on Energy
	Air	1.1807	Lufthansa; incl. IATA t-km user charges
France	Road	3.0667	Scenarios developed by Ecosys® 40 t 500 km
	Rail	0.8461	Fuel taxes, Compte satellite des transports
	Air	0.3	Air France; incl. IATA t-km user charges
	Shipping	0.8461	Fuel taxes, Compte satellite des transports
Netherlands	Road	1.4763	Scenarios developed by Ecosys® 40 t 500 km
	Rail	–	–
	Air	0.848	Northern Europe; incl. IATA t-km user charges
Switzerland	Road	2.2375	Scenarios developed by Ecosys® 28 t 500 km
	Rail	0.05	CFF; Incl. taxes linked to electricity production
	Air	0.9437	Sair Group; incl. IATA t-km user charges

1. Charges for infrastructure use are included. For road, they are made of tolls (F) or set prices (Eurovignette, Swiss RPL), depending on the country user charges regime. For air, they are made of user charges, incl. airport charges.

Sources: See also Ecosys®, 1998 and Pillet, 1998.

Table A4. **Government infrastructure expenditures: *Transfer rate***

Country	Mode	Transfer Rate	Source
Germany	Road	–0.045	Bundesministerium für Verkehr
	Rail	–	
	Air	–	
France	Road	0.014	Compte satellite des transports
	Rail	0.7	Compte satellite des transports
	Air	–	
	Shipping	–	
Netherlands	Road	–1.2684	Dutch Road Account
	Rail	–	
	Air	–	
Switzerland	Road	0.093	Swiss Road Account
	Rail	1.00	CFF Yearly Report
	Air	–	

Sources: See also Ecosys®, 1998 and Pillet, 1998.

Input shares

Table A5. **Input share structures**[1]

Country	Mode	Capital	Labour	Fuel	Total	Source
Germany	Road	41.71	51.25	7.04	100.00	Operating Costs Structure (BGL)
	Rail	41.00	55.45	3.55	100.00	D Bahn Reports
	Air	50.51	37.78	11.71	100.00	Lufthansa Reports
France	Road	43.27	51.04	5.69	100.00	Compte satellite des transports
	Rail	34.66	62.22	3.12	100.00	Compte satellite des transports
	Air	50.51	37.78	11.71	100.00	Compte satellite des transports
	Shipping	25.69	71.11	3.2	100.00	Compte satellite des transports
Netherlands	Road	45.60	45.80	8.60	100.00	Dutch NEA
	Rail	–	–	–	–	–
	Air	65.00	21.00	14.00	100.00	IATA (Northern Europe)
Switzerland	Road	40.40	54.49	5.11	100.00	Operating Costs Structure (ASTAG)
	Rail	37.85	46.00	16.15	100.00	CFF Reports
	Air	59.30	30.20	10.50	100.00	Sair Group Reports

1. Input shares were calculated on an operating costs basis: on a share/day basis with respect ro road (scenarios), and on a share/year base with respect to rail, air and inland shipping.

Table A6. **Ecosys' scenarios – Models vs. real world "routages"**

Data – March, 1997

	Fuel prices without taxes (FRF)	Change (CHF)	Fuel prices without taxes (CHF)	Fuel consumption, 40 t: 32 l/100 km
Germany	1.64	83.54	0.4066	*Ad valorem* taxation rate:
France	1.38	24.79	0.3421	Net total/fuel consumption/fuel price × 100
Netherlands	1.62	74.3	0.4016	
Switzerland	–	–	0.3500	Net taxation rate per
EU (ECU)		163.1		Net total/tons/km

	Scenarios: 40 t, 500 km (CH: 28 t)			**Tests (real world): 40 t (CH: 28 t)**		
	Switzerland (CHF) 28 t	Switzerland (ECU) 28 t	Net taxation rate tkm (ECU)	Bâle-Bellinzona 247 km (CHF)	Idem (ECU)	Net taxation rate tkm (ECU)
Taxes	16.97	10.40	0.0055	11.89	7.29	0.0063
F. Excise duties	107.39	65.84		53.70	32.92	
User charges	11.11	6.81	*Ad valorem*	11.11	6.81	*Ad valorem*
– Exemptions	10.17	6.24	tax rate	5.08	3.11	tax rate
Net total	125.3	76.82	223.75	71.62	43.91	292.3265
	France (CHF) incl. 250 km AREA highways	France (ECU)	Net taxation rate tkm (ECU)	Paris-I border Mont-Blanc Tolls only 630 km (CHF)	Idem (ECU)	Net taxation rate tkm (ECU)
Taxes	37.75	23.15	0.0051	51.45	31.55	0.0074
F. Excise duties	91.01	55.80		114.89	70.44	
User charges	69.52	42.62	*Ad valorem*	175.19	107.41	*Ad valorem*
– Exemptions	30.42	18.65	tax rate	38.41	23.55	tax rate
Net total	167.86	102.92	306.6702	303.12	185.85	438.6394

Table A6. **Ecosys' scenarios – Models vs. real world "routages"** *(cont.)*

Data – March, 1997

				Nevers-Clermont-Bordeaux "Nationales" 519 km	Idem (ECU)	Net taxation rate tkm (ECU)
Taxes				35.14	21.555	0.0029
F. Excise duties				94.42	57.89	
User charges				0.00	0.00	*Ad valorem*
– Exemptions				31.56	19.35	tax rate
Net total				98.00	60.09	172.5688
	Germany (CHF)	Germany (ECU)	Net taxation rates tkm (ECU)	NL border-CH border 545.5 km (CHF)	Idem (ECU)	Net taxation rate tkm (ECU)
Taxes	27.7	16.98	0.0030	29.80	18.27	0.0030
F. Excise duties	82.87	50.81		90.64	55.57	
User charges	10.02	6.14	*Ad valorem*	10.02	6.14	*Ad valorem*
– Exemptions	22.32	13.68	tax rate	24.41	14.97	tax rate
Net total	98.27	60.25	151.0708	106.05	65.02	149.0570
	Netherlands (CHF)	Netherlands (ECU)	Net taxation rate tkm (ECU)	Rotterdam-D border 170 km (CHF)	Idem (ECU)	Net taxation rate tkm (ECU)
Taxes	29.37	18.01	0.0029	12.29	7.54	0.0037
F. Excise duties	81.94	50.24		28.17	17.27	
User charges	9.58	5.87	*Ad valorem*	9.58	5.87	*Ad valorem*
– Exemptions	26.03	15.96	tax rate	8.95	5.49	tax rate
Net total	94.86	58.16	147.6290	41.09	25.19	186.0295

1. Results from the real world tests are different from the ones obtained from Ecosys scenarios only to the extent that either total km differ (CH, NL) or the real world road is made of a different mix of tolls/no toll highways.

Notes

1. We expressly wish to thank IATA Geneva and London, SAirGroup, Lufthansa, SBB CFF FFS, SET Switzerland, SES France, ASTAG Switzerland, Federal Statistical Offices of Germany and Switzerland, and the Dutch NEA for valuable co-operation in the data collection. Thanks are also due to Jan Pieters, Steve Perkins, Helen Mountford and Nicole Zingg for key contributions to this study.
2. Due to lack of data, inland shipping was analysed for one country (France) only.
3. The reason is twofold: on the one hand, actual costs for standardised hauls for rail and air are not currently available (actual operating costs are much more transparent for road haulage than they are for rail and air freight transport); on the other hand, rail, air and inland shipping are exposed to much less variations in actually paid taxes than road transportation is, so calculations based on annual operating costs can be a fair proxy for the actual costs. Consequently, the results of the study can be partitioned into:
   – "in depth" case-studies for road (CH, NL, D, F);
   – "in principle" case-studies for rail (CH, D, F), air (CH, NL, D, F). For NL, the rail data was incomplete;
   – "reference" case-study for inland shipping (F).
4. Although inaccurate, this assumption is not far from the truth if the supply of fuel is elastic and the demand for transport services is inelastic, as it generally is.
5. Although tolls, airport charges and the like can be seen as payments for (public) services, not unlike the purchase of fuels, the prices of these (public) services are often subject to political decision making as well. Consequently, in this study they are treated like taxes.
6. For a more comprehensive description of the effective tax rate on the marginal costs of production, and another application of the analysis, see Duanjie Chen (in this volume).
7. Vehicle taxes are lumped together with taxes on fuel and user fees, taking fiscal depreciation rules into account. Capital taxes do not include taxes on profits.
8. It should be noted that, in reality, a tax on an input will be split between producers and consumers according to the relative price elasticities of demand and supply for that input. Allowing for this effect would change the term t into βt, in which β is the ratio of the actual price increase over the tax or charge ($0 < \beta < 1$).

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Energy Support Measures and their Environmental Effects: Decisive Parameters for Subsidy Removal

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1. INTRODUCTION

The goal of this report is to find generalised statements ("decisive parameters") about any characteristics of support measures to energy which might be used to predict their negative environmental effects. This would enable policy makers to rank different options for support removal according to their environmental impacts. The subject material here is the set of case studies on the reform of energy subsidies conducted under supervision of the OECD and published as *Environmental Implications of Energy and Transport Subsidies*, Volumes 1 and 2 (OECD, 1997*a* and 1997*b*) and summarised in OECD (1997*c*). Because these studies did not use the same methodology, comparing their findings and drawing general conclusions from them is difficult. Therefore, this study tries to make their results comparable by drawing out those elements that are relevant to the aims of the "wide-ranging" study of the OECD on the impacts of tax and subsidy policies on the environment (OECD, 1998).

This paper is organised as follows. The next section explains the methodology used to deduce generalisations from the different case studies. As the case studies differ in many respects – such as the scope of analysis, the methodology applied, and the basic reference scenarios used – an overall framework for assessment is necessary. Subsequently, each of the studies is presented in more detail, describing to what extent they provide (empirical) insight into the issues relevant to the current project. Thus, for each study, the findings on the linkage between support removal and environmental effects are briefly summarised for standardisation purposes. Finally, any overall conclusions that can be drawn on potentially decisive characteristics of the environmental effects of support measures in the energy sector, or their removal, are presented.

2. METHODOLOGY

In order to incorporate the set of previous case studies on support removal in the energy sector and their environmental effects (OECD, 1997*a* and 1997*b*) into the "wide-ranging" study, the following conceptual model has been applied. The approach starts by dividing existing and potential energy technologies according to whether they have relatively environmentally harmful or less harmful characteristics. Next, an analysis is conducted of how *economic* (decision) variables, like costs and prices, are affected by support removal in the studies under review, and to what extent this may induce substitution towards relatively less environmentally damaging technologies.

A technology is defined as less environmentally harmful if it is less pollution intensive than the alternative according to the revealed preferences of governments. For instance, governments perceive climate change and acid rain as pollution problems, implying a preference for reducing the emissions that lead to these problems. Specifically, governments consider the reduction of emissions such as CO_2, SO_2 and NO_x (per unit of energy output) an important environmental goal, as well as improvements in energy efficiency (reduced energy input per unit of output or consumption).

With these concerns in mind, one can establish a rough and ready approach to assessing the relative environmental effects of different energy technologies. Energy technologies are ranked in this report as environmentally harmful or less harmful according to a global assessment of their overall environmental impact. For instance, coal-based energy production accompanied by flue-gas-desulphurisation (FGD) technology is less environmentally harmful than coal burning technologies which use the same coal inputs but do not apply any pollution abatement techniques. Similarly, cogeneration and other energy efficiency improvements are relatively less environmentally harmful as they result in higher energy efficiency per unit of desired output (electricity, power). Non-fossil fuel inputs are also generally preferable from an environmental perspective.

An overall assessment of the environmental effects of different energy technologies would, preferably, also include the *indirect* environmental effects of substitution, including both the energy and material components of production techniques. Thus, one should consider changes in material intensities per unit of output, as, for instance, solar-powered electricity requires additional investments in materials to build solar cells. Other indirect effects stem from changes in other parts of the production and consumption system induced by changes in energy or output prices. An example is the overall energy efficiency improvements that result from higher energy prices.

To analyse the overall environmental effects of support removal, one would ideally start from a rather general conceptual framework as presented in the "wide-ranging" study of the OECD. The framework should, first of all, account for the fact that the specific composition of environmental effects depends on the choice of technologies. Next, the representation of these technologies should not only include the usual inputs such as labour and capital, but also energy and materials as inputs. From an overall macroeconomic perspective it is important also to account for substitution (or complementarity) between energy and material resources (*e.g.*, higher energy prices might induce a shift away from primary aluminium production to secondary). Finally, linkages between the choice of technologies used and parameters like the prices of the different inputs and environmental regulations in a particular country should be established. This conceptual framework can be illustrated with the following representative (long run) production function:

$$f\,(\boldsymbol{y}, \boldsymbol{a}, \boldsymbol{k}, \boldsymbol{e}, \boldsymbol{m}, \boldsymbol{p}) = 0 \qquad (1)$$

Here $\boldsymbol{y}$ is the desired output vector (volume) and $\boldsymbol{p}$ the undesired output or pollution vector, while the vectors of labour ($\boldsymbol{a}$), capital ($\boldsymbol{k}$), energy ($\boldsymbol{e}$) and material ($\boldsymbol{m}$) represent input vectors.

In more practical studies, however, the specific mix of relevant vector components usually varies according to the level of analysis, the feedback mechanisms included (as related to these and other possible variables) and the time aspect of the adaptation period [transition path to (a) different technology(ies)]. Indeed, the studies under review do not use this general framework but concentrate only on some variables while excluding others. Although some of them include capital and even budgetary recycling, most of the studies concentrate on partial effects particularly as they relate to changes in the energy and pollution vector. Thus the studies implicitly separate the characteristics of the choice of a specific energy technology from the choice of other inputs of the generalised production function. Therefore, the studies under review are better characterised by a composite function like:

$$g\,[\boldsymbol{y}, \boldsymbol{m}, h\,(\boldsymbol{a}, \boldsymbol{k}), j\,(\boldsymbol{e}, \boldsymbol{p})] = 0 \qquad (1')$$

This production function more explicitly characterises energy technologies through the sub-production function j and has the advantage that changes in energy subsidies are directly related to the choice of different energy-pollution combinations. Thus, studies which concentrate on the choice of energy technologies alone can be represented assuming changes in the other variables as given. Using classifications of energy technologies as exogenous information, this conceptual framework can be used to interpret the results of the studies on how subsidy removal would affect the environment through their effects on the choice of specific energy technologies.

With these types of production function in mind, it is possible to examine the question raised in the "wide-ranging" study of whether changes in subsidies based on energy and material inputs might have different consequences over time compared to subsidies dependent on other inputs, such as capital. For such an analysis, one might think of (1') in terms of its dual cost function, with prices for both the inputs and the outputs. For instance, if a subsidy on a specific input (like oil) is removed and the energy technology applied has high cross-fuel substitutability (*e.g.*, towards gas within the vector ***e***), one might expect a relatively short adaptation period towards the technology based on the substitute fuel. This can be analysed without direct reference to the other inputs in the sub-production function *h*. If instead a capital subsidy to the coal industry is terminated, this might be expected to have a long-run effect, as existing capital equipment is much less substitutable in the short-run, compared with fuel inputs. In such a case, both sub-production functions *h* and *j* are relevant and together they will determine the (long-run) choice of technology.

Given that the purpose of this study is to try to derive general statements for the "wide-ranging study", this analysis adopts a broad definition of subsidies, referred to as"support" in the following. Support can be defined as *all kinds of measures that discriminate against "sound environmental practices"* (OECD, 1998). It thus includes all kinds of financial support as well as regulations that discriminate against environmentally benign practices, as applied to energy technologies in this study. The concept is defined as broadly as possible on purpose, as the studies under review differ considerably in to what extent they include different types of support measures.

In order to establish generalisations about the linkages between the removal of support measures and their environmental effects, as found by the case studies under review, three questions are addressed in particular:

1. What makes support measures work, or what are the driving forces explaining the environmental effects of support measures (given their point of incidence, support base, etc.)?
2. How do the driving forces relate to the characteristics of the recipient sector under analysis?
3. What are the assumptions used about the exogenous circumstances, such as environmental policies or autonomous developments, in the base case scenario as compared with the support removal scenario?

Answering the first question will indicate the mechanisms that are analysed in the different case studies. These are important to know because they explain what the effects of support removal will be. The second question accounts for the different circumstances that exist in different recipient sectors because they operate in rather different market environments. Finally, standardisation procedures also require that appropriate notice is taken of the autonomous policy framework within which the support removal is analysed, such as the strictness of existing environmental policies and the level of support phase-out already assumed *a priori*. Together, the answers to these questions can be used to sift out potential generalisations about the expected environmental effects of support removal.

Next, each of the case studies will be reviewed separately with respect to how the expected environmental effects that result from support removal relate to the different types of support measures examined, given their assumptions about the environmental policies in place and whether – and to what extent – support phase-out is already assumed in the base case scenario. The interpretation of most of the studies has been checked with the authors responsible for the studies, all of which are documented in the OECD report on E*nvironmental* I*mplications of* E*nergy and* T*ransport* S*ubsidies*, Volumes 1 and 2 (OECD, 1997*a* and 1997*b*).

3. REVIEW OF THE PREVIOUS CASE STUDIES USING THE CHARACTERISTICS APPROACH

3.1. Energy subsidies in the US (Shelby *et al.*)

The *focus* of this study was the effect of removing energy subsidies in the US on CO_2 emissions (through their effects on overall energy use in the US economy). Two *methods* were employed to examine this: one (DFI) was a simulation analysis with a bottom-up energy sector model, the other (DJA) was a top-down Computable General Equilibrium (CGE) model with an embedded energy sector calibrated for the US in 1995. The findings are summarised in Table 1 according to the methodology that was explained in Section 2 above. The analysis of the environmental effects was restricted to CO_2 emissions only.

This study showed that:

1. if the pollution intensity of the *status quo* technology employed by the "recipient sector" is high (*e.g.*, coal dominated), the removal of subsidies can reduce negative environmental effects considerably;
2. the withdrawal of tax or user fee exemptions is more effective than the removal of support measures that affect long-run marginal costs (*e.g.*, support to capital, R&D) in terms of reducing total tons of polluting emissions, but less so in terms of reducing total tons of CO_2 emissions per $ subsidy removed;
3. removing support to industrial consumers is more effective in reducing pollution emissions than the removal of support to households (because industrial consumers have a higher cost consciousness and have more alternative options available);
4. the environmental benefits of subsidy removal are relatively small if (energy) prices are low;

Table 1. **Energy subsidy removal in the US**

	Examples	Mechanisms explaining environmental effects of support reduction
	Characteristics of support measures:	
* Producer subsidies	– Tax exemptions for coal and oil use (municipal utilities, user fees for abandoned mines and oil reserve); – Capital facilities (low interest loans, depreciation allowances); – Limited liability and high R&D spending to nuclear industry.	– Impacts are small in the short-run, though considerable in the long-run (higher energy prices account for considerable scale effects); – Relative importance of the substitution effects induced by different subsidies depends on the relative importance of environmentally harmful technologies (with high CO_2 emissions) in the input mix.
* Consumer subsidies	– Low income household credits; – Preferential treatment housing mortgages; – Tax exemption on employee transportation.	– More expensive housing causes smaller, less energy-intensive houses to be built; – Higher price of transport reduces excessive consumption of fuel oils.
	Characteristics of the recipient sector:	
* Energy producers and consumers	– Undistorted market in DJA study; – Unclear for the DFI study.	– Substitution possibilities depend on the assumed energy elasticities in the input mix of the fully rational (forward looking) agents.
	Circumstances:	
* Environmental policy	– Unchanged compared to the status quo (for both models); – Assumption of long-run stabilisation of CO_2 emissions without policy intervention in the DJA model.	– Environmental effects are restricted to CO_2 emissions only.
* Subsidy phase-out assumed in the status quo	– No.	– Effects analysed compared to subsidised status quo.

5. the environmental benefits of removing subsidies to complementary goods can be considerable;
6. the long-run environmental effects of subsidy removal might be underestimated in the DJA model due to an assumption of long-run stabilisation of CO_2 emissions in the base case (*i.e.*, environmentally benign backstop technologies are already included in the reference scenario).

3.2. Energy subsidies in Russia (Gurvich *et al.*)

The *focus* of this study was the effect of the liberalisation of energy prices – through a reduction in the gap between local and world market energy prices in the Russian economy – on CO_2, SO_2 and NO_x emissions. This effect was analysed through the impact of price liberalisation on overall energy use in the economy. The *method* employed was a simulation analysis with a comparative input-output technology matrix. This matrix compared "old", pollution-intensive Russian technologies with "modern", less pollution-intensive technologies from the West with backward adaptation for the years 1990-1994. See Table 2 for the *summary* of this study.

This study showed that:

1. the removal of support measures is particularly effective if the recipient sector is subject to (autocratic) central planning ("purchase obligations") and blessed with large energy resource endowments, because decentralised (price-based) incentives for energy efficiency are almost absent and energy prices tend to be low in general;
2. removing support to industrial consumers is more effective compared to the removal of support to households (higher cost consciousness, more alternative options available for industry);
3. the high rate of Combined Heat Power (CHP) and gas penetration in the past, as well as its supposed growth in the near future, are not market-based but due to (partly arbitrary) planning;
4. support elimination is found to be more effective in achieving emission reductions than increasing environmental (tax) policy.

3.3. Accelerated phase-out of coal subsidies in OECD Member countries (DRI)

The *focus* of this study was the effect on CO_2, SO_2 and NO_x emissions of an accelerated removal of subsidies to the coal industry in several OECD Member countries. This effect was analysed through the impact of the removal of the subsidies – on top of already existing phase-out schemes – on coal production and consumption, as well as overall energy use in the different economies. The *method* employed was a simulation analysis using energy embedded country-specific and internationally linked macroeconomic submodels (including world energy supply and demand conditions). The findings of this study are *summarised* in Table 3.

Table 2. **Energy subsidy removal in Russia**

	Examples	Mechanisms explaining environmental effects of support reduction
	Characteristics of support measures:	
* Producer subsidies	– Budgetary subsidy to coal producers; – Low domestic oil prices through export quotas and duties; – Use of export revenues from gas/oil to cross-subsidise undervalued domestic supply.	– Reduction of energy price subsidies (compared to initial 1990 level) raises the relative price of energy, inducing *additional* substitution to more modern capital intensive and both energy and pollution extensive technologies (per unit of output); – Higher energy prices reduce both industrial and household demand for energy (per unit of output); – Reduction of emissions per unit of output are not only due to investment in more efficient technologies, but also to autonomous (additional) penetration of gas in the Russian economy.
* Consumer subsidies	– Reduced prices to households financed by local government and other consumers (cross-subsidies); – Purchase obligations common due to central planning.	
	Characteristics of the recipient sector:	
* Energy producers and users	– Energy supply sector is politically constrained on export/import markets (closed economy); – Centrally planned monopolistic supply with high extraction rates (due to large domestic inventories) and low conservation efforts.	– Price-based competition triggers more attention to the cost of energy, thereby inducing investments in energy efficiency by both the energy supply industry and industrial energy consumers (investments in more efficient modern technologies and so-called "natural decline"); – Future gas penetration assumed irrespective of subsidy removal.
	Circumstances:	
* Environmental policy	– Initially (1990) almost no relevant environmental policies, after liberalisation (1994) small impacts (nevertheless, the more environmentally-friendly Combined Heat and Power (CHP) and gas are common in power generation); – effects of additional environmental policies included in scenarios.	– Absolute reductions of emissions in 2010 (compared to 1990 level) is mainly due to initial reduction in GDP and demand for energy between 1990 and 1994.
* Subsidy phase-out assumed in the status quo	– No subsidy elimination in 1990, and partial elimination by 1994 (still considerable in all areas of energy use).	– Effects analysed compared to actual 1990-1994 policies (with subsidies, no environmental policy); – Subsidy elimination found to be considerably more effective if additional environmental policies were added.

Table 3. **Accelerated coal subsidy removal in OECD countries**

	Examples	Mechanisms explaining environmental effects of support reduction
	Characteristics of support measures:	
* Producer subsidies	– Purchase obligations by the electricity sector for the output of the coal sector in accordance with long-term contracts; – Direct payments to the coal sector.	– Freedom to choose inputs in electricity sector leads to substitution towards the import of cheaper, less environmentally damagin fuels (= low sulphur coal) in some heavily subsidised countries (Spain, UK, Japan); – Fall in the operating costs of the electricity sector (fuel costs are 25% of total costs) causes an increase in the demand for electricity; – Only a small increase in the world market price of coal is estimated and, therefore, of the competitive position of CCGT.
* Consumer subsidies	– Not included.	
	Characteristics of the recipient sector:	
* Coal producers	– Coal produced in countries which subsidise the coal industry is usually not competitive on the world market (the coal prices are too high).	– The cost of the supported, environmentally malign fuel (high sulphur coal) rises relative to the unsupported, less environmentally damaging fuels (low sulphur coal, gas).
	Circumstances:	
* Environmental policy	– The Large Combustion Plant Directive of the EU is assumed to be implemented, but no additional regulations, such as CO_2 constraints (environmental policies differ across countries).	– *Rate* of gas penetration is only slightly affected; – Cost of the pollution reduction assumed in the base case is already sufficient to induce some substitution towards gas.
* Subsidy phase-out assumed in the status quo	– Some phase-out path is included in the reference scenario.	– Effects shown are compared to *autonomous* phase-out path which already includes some phasing out of coal subsidies.

This study showed that:

1. subsidies tend to be particularly distortionary if they apply to environmentally harmful fuels (like sulphur rich coal inputs to the electricity sector) as the price of fuels tends to dominate the long-run choice of the energy supply technology;
2. the lack of freedom to choose energy sources that is a result of purchase obligations, prevents environmentally less harmful alternatives from penetrating the market (especially because these obligations tend to be long term contracts);
3. even the removal of subsidies to producers in the form of fuel purchase obligations may reduce the price of the downstream (energy) product (so long as the substitution effect dominates the income effect) revealing a clear double dividend from support removal in such cases;
4. the continuing attractiveness of the comparatively environmentally harmful fuel (low sulphur) coal relative to gas (additional CCGT penetration has been limited) is explained by the fact that no new environmental regulations are included in the base case other than the implementation of the EU Large Combustion Plant Directive. As such, burning coal in an existing coal-fired plant is found to be more financially attractive than retiring the plant early and replacing it by a gas plant under the conditions assumed in the study;
5. it is not easy to understand to what extent differences in outcomes between countries of subsidy removal might be affected by differences in environmental regulations between the countries in the base case scenario.

3.4. Support to electricity in Australia (Naughten *et al.*)

The *focus* of this study was an analysis of the effects on CO_2, SO_2 and NO_x emissions of removing market distortions in the Australian electricity sector and natural gas industry. These effects occur through changes in electricity supply and demand, including through energy efficiency. The *method* employed was a country-specific simulation analysis of cost efficient energy markets using the bottom-up MENSA model (which is a local variant of MARKAL). Table 4 provides a *summary* of this study.

The study concluded that:

1. support to the existing recipient electricity industry prevents the environmentally less harmful technologies from penetrating the energy market, especially CHP – and gas-based technologies;

Table 4. **Support removal in the electricity sector in Australia**

	Examples	Mechanisms explaining environmental effects of support reduction
	Characteristics of support measures:	
* Producer subsidies	– Any deviation of prices from undistorted costs, including: – Capital subsidies (low interest loans; loan guarantees), – State-based systems of supply with limited interconnections; But excluding: – R&D expenditures, – Tax facilities; – Discriminatory terms of access (mainly for privately generated electricity).	– Allowance for interstate connections improves substitution possibilities by the less environmentally damaging fuels (*e.g.*, gas for coal see below); – Removal of discriminatory access allows private generators to sell their surplus to the national grid, improving the energy efficiency of the system (CHP); – Growing importance of modular (decentralised) technology (*e.g.*, cogeneration) due to a rise in risk perception associated with the long lead time of highly capital intensive electricity supply industry (ESI); – Capital subsidy removal reduces the relative attractiveness of the more environmentally malign technologies (which are usually more capital intensive, such as coal as compared with CCGT technology).
* Consumer subsidies	– Cross-subsidies between regions and different consumers (from large to small); – Implicit subsidies to large industrial customers.	– Reducing cross-subsidies to households allows the more energy sensitive consumers to invest in more energy extensive technologies.
	Characteristics of the recipient sector:	
* Electricity and gas industries	– Local markets with limited interconnections between the states (both for electricity and gas); – Several market distortions in place due to local monopolies.	– Small substitution elasticities between coal and gas exist, mainly because of the limited physical access of gas to the ESI (and thus the requirement for large investments in infrastructure to switch to gas).
	Circumstances:	
* Environmental policy	– One base case assumes no changes in environmental policy compared with the status quo; – Another includes the introduction of an upper limit on CO_2 emissions.	– The cost of implementing environmental policy measures is shown to be considerable if market distortions are not removed.
* Subsidy phase-out assumed in the status quo	– Market distortions are removed in practice; – and are assumed to be absent in the base case.	– The effects of subsidy removal are compared with both base cases (with and without the CO_2 policy).

2. subsidies related to long-run marginal costs (especially capital facilities) are important as the existing environmentally more harmful technologies are usually rather capital intensive (for example, coal compared to gas and CHP);
3. the removal of (cross-) subsidies to households is less effective environmentally compared with removing (cross-) subsidies to industrial consumers because the latter are more (energy) cost sensitive;
4. the (local) monopoly structure of the recipient industry prevents the easy access of environmentally less damaging technologies, which tend to be more decentralised;
5. environmental policy is more expensive if subsidies are not removed.

3.5. Support to electricity in Italy (Tosato)

The *focus* in this study was the effect on CO_2, SO_2 and NO_x emissions of removing both net and cross-subsidies in the Italian electricity sector. Support to both consumers and producers is included in the analysis. The *method* employed to calculate the effects was a country specific simulation analysis of cost efficient energy markets using a bottom-up model (a variant of MARKAL). The study is summarised according to our methodology and is presented in Table 5.

This study found that:

1. if the pollution intensity of the *status quo* technology employed by the "recipient sector" is high (*e.g.*, oil dominated), the removal of subsidies can reduce the negative environmental effects considerably, except where the sector imports electricity with low pollution intensity;
2. withdrawal of tax exemptions is more effective environmentally in the short-run compared with the withdrawal of capital related subsidies as the latter do not affect the economic viability of existing plants while the withdrawal of the former raises the consumer price, thus reducing demand immediately and stimulating supply of environmentally less harmful technologies such as renewables and CHP from independent producers;
3. in the long-run, however, withdrawal of capital subsidies is just as important because power planning decisions are strongly affected by these subsidies;
4. environmental policy is absolutely necessary to attach an appropriate price to the negative environmental impacts of energy production and use, but it is more expensive if subsidies are not removed as the two policies are synergistic;

Table 5. **Support removal in the Italian electricity industry**

	Examples	Mechanisms explaining environmental effects of support reduction
	Characteristics of support measures:	
* Producer subsidies	– Tax exemptions on fossil fuels; – Subsidies to capital facilities (lower economic margins); – Cross-subsidies to (cheap) electricity imports.	– Average electricity prices are raised, thus reducing demand (direct effect) and the diffusion of district heating (indirect); – Higher prices also stimulate environmentally less harmful technologies (such as renewables and CHP from independent producers) as they become more competitive; – Removal of import subsidy might increase emissions (due to a reduction in the import of CO_2-free nuclear electricity).
* Consumer subsidies	– Low VAT rate on energy consumption; – Discounts for some industrial producers.	
	Characteristics of the recipient sector:	
* Electricity industry	– Monopolistic market with one central player (ENEL); – Some room for internal producers of electricity; – Considerable electricity imports.	– Subsidies are important for the choice of new plants, but less important for the early replacement of existing ones.
	Circumstances:	
* Environmental policy	– Vigorous environmental policy included in scenario (acid rain agreements and a CO_2 tax).	– Cost of environmental control policies considerably lower if both CO_2 policy and subsidy removal are in place.
* Subsidy phase-out assumed in the status quo	– Partial phase-out in practice; – In benchmark scenario, no subsidy phase-out but vigorous environmental policies assumed (although acid rain policy not very binding).	– Effects are shown relative to each other; – CO_2 policy and subsidy phase-out are synergistic (they are more effective applied together than each taken alone).

5. although emission intensity might be lower due to international trade in electricity, it is unclear whether this is sufficient to compensate for the losses in energy efficiency that result from larger transmission distances.

3.6. Electricity market reforms in Norway (Jensen *et al.*)

The *focus* of this case study was to analyse the effects of the removal of market distortions that existed in the Norwegian electricity sector in 1991 on electricity supply, energy consumption, and CO_2 emissions. The *method* employed was a qualitative analysis of actual developments in electricity production and consumption in Norway between 1980-1995. This study is summarised in Table 6.

The findings of this study are:

1. even if the pollution intensity of the *status quo* technology employed by the "recipient sector" is low (*e.g.*, water dominated), removal of support to the electricity sector can still reduce negative environmental effects considerably through downstream fuel choices (*e.g.*, to electricity from water power instead of from oil);
2. if the sector exports some of this electricity, and it is produced with a relatively low pollution intensity compared to production in other countries, the net environmental effects of subsidy removal may actually be negative as it may encourage replacement of this relatively environmentally benign electricity source with more damaging fuels;
3. lack of competition due to local purchase obligations causes over-investment in recipient industry and environmentally harmful downstream interfuel adjustments (switch from hydro-powered electricity to oil-powered);
4. losses in energy efficiency through international trade seem to be less problematic in the case of a relatively environmentally benign technology.

3.7. Support to electricity in the UK (Michaelis)

The *focus* here is the effect of the removal of support measures (subsidies and market distortions) in the UK electricity industry on CO_2, SO_2 and NO_x emissions. These effects were analysed through the impact of support removal on supply decisions in the electricity supply industry (ESI). The *method* used was a simulation analysis of cost efficient power generation decisions using projections of energy use and CO_2 emissions employed by the UK government. The major characteristics of this study are summarised in Table 7.

This study found that:

1. subsidies are again crucial for power plant decisions through their impact on the relative prices of the various fuels;

Table 6. **Support removal in the Norwegian electricity sector**

	Examples	Mechanisms explaining environmental effects of support reduction
	Characteristics of support measures:	
* Producer subsidies	– Before market reforms, producers were required to meet demand through local production.	– Competition reduces over expansion in (local) power capacity through interregional and international trade and, therefore, causes electricity prices to fall; – Lower power prices increases electricity consumption and reduces oil consumption through interfuel substitution; – Expansion of international trade reduces the need for environmentally malign peak load technologies in other countries.
* Consumer subsidies	– Consumers face purchase obligations in their own jurisdiction.	
	Characteristics of the recipient sector:	
* Electricity producers	– Local markets with local monopolies; – Strong regional variance in (monopoly) prices.	– Freedom to choose supplier introduced more cost-effective planning through (co-ordinated) interjurisdictional trade.
	Circumstances:	
* Environmental policy	– Taxes on electricity compensate for the decline in net-of-tax-prices (with only a minor decline resulting in real tax-inclusive prices); – Tax on CO_2 emissions; – Incentives for investment in energy efficiency.	– Set of incentives guarantees both interfuel substitution towards environmentally less damaging electricity and investment in more energy efficient technologies.
* Subsidy phase-out assumed in the status quo	– Phase-out included since reforms began in 1991.	– Effects derived from actual developments.

Table 7. **Support removal in the electricity sector in the UK**

	Examples	Mechanisms explaining environmental effects of support reduction
	Characteristics of support measures:	
* Producer subsidies	– Purchase obligations for coal inputs through long-run contracts (negative subsidy to ESI); – Fossil fuel levy to finance excess market price of nuclear energy; – Capital facilities to nuclear power plants (low Required Rate of Return, limited liability); – High R&D funding to nuclear power.	– Capacity planning for ESI dominated by fuel costs; – Penetration of environmentally less damaging gas technology (CCGT) due to the higher net-of-subsidy price for coal; – Low RRR essential to capital intensive plants (like coal and nuclear power plants); – Increased electricity supply (due to the artificially high selling prices including subsidies).
* Consumer subsidies	– No VAT on electricity.	– Increased prices through raising VAT leads to lower consumer demand for electricity.
	Characteristics of the recipient sector:	
* Electricity producers	– Transitory phase from monopolistic ESI and input delivering industries (coal, gas) towards privatised and market-based industry.	– Lack of competition creates over-investment in generating capacity and therefore high-priced electricity.
	Circumstances:	
* Environmental policy	– Flue Gas Desulpherisation (FGD) required (for UK to meet acid rain agreements); – Upper limit on gas consumption by the ESI; – No CO_2 policy assumed.	– Competitiveness of gas simply due to high efficiency of CCGT technology and low (net-of-subsidy) fuel cost (at current prices).
* Subsidy phase-out assumed in the status quo	– Considerable, though gradual, phase-out already agreed upon in practice; – and included in the reference scenario.	– Effects shown relative to unsubsidised reference scenario; – Reference path already includes non-renewal of coal contracts (reducing SO_2 and NO_x emissions considerably).

2. if the pollution intensity of the *status quo* technology employed by the "recipient sector" is high (*e.g.*, based on coal or nuclear power), the removal of subsidies can reduce the negative environmental effects considerably;
3. subsidies to long-run marginal costs (especially capital facilities) prevent the penetration of environmentally less damaging technologies as (currently) the environmentally malign technologies tend to be more capital intensive (coal and nuclear compared with gas);
4. the savings from emission reductions due to support phase-out tend to dominate downstream indirect effects through lower electricity prices;
5. lack of competition due to monopolistic power supply causes over-investment in the recipient industry.

4. TOWARDS GENERALISATIONS

In this section, some generalisations are suggested based on the results of the different case studies. The most important generalisation can be drawn from the fact that in none of the case studies is the removal of support found to induce *negative* environmental effects. In most of the studies these effects are shown to be positive, although in some cases the effect is quite small. If the pollution intensity of the *status quo* technology employed by a "recipient sector" is high (*e.g.*, oil or coal dominated), the removal of subsidies reduces negative environmental effects considerably. This conclusion remains valid even if the recipient sector uses a relatively environmentally benign technology (see the case of Norway). However, it is not valid for support to environmentally less damaging technologies which are not yet locked-in to existing technology trajectories. Therefore, the first general conclusion is that:

in the short-run, support removal to the energy sector is good for the environment except for those cases where this support is explicitly aimed at the use of environmentally benign technologies.

Thus, a positive relationship between support removal and beneficial environmental effects holds. The main reason is that decentralised, cost-efficient and relatively environmentally less harmful technologies exist (for example, CHP or gas-based CCGT), but are prevented from entering the market because of price-based support and regulatory constraints (*e.g.*, purchase obligations, discriminatory access) on the one hand, and a monopolistic market structure on the other hand. Moreover, the removal of market distortions that cause imperfect competition tends to stimulate technologies which are less capital intensive, more decentralised and modular, which tend to be less environmentally damaging. However, typically these environmentally less damaging technologies, like solar or wind power, are also capital intensive, requiring specific targeting of support in the long-run.

The issue of targeting is important with respect to the removal of support to existing technologies. Support measures might raise the cost of a particular technology, which, if the support is removed, improves the relative attractiveness of a potentially cheaper, less environmentally damaging alternative. At the same time, however, support measures can reduce the cost of a technology employed such that, if the subsidy is removed, the overall consumption of this product may be reduced, thus reducing the overall environmental effects. Therefore, in order to get a feeling for the importance of a specific subsidy in terms of its environmental effects, it is important to relate the potential savings in environmental harm from the subsidy removal to the amount of the subsidy paid that actually reaches the recipient sector. Most of the case studies examined reveal the importance of the pollution intensity of a particular recipient sector in the *status quo*.

The second general conclusion is therefore:

support removal should be concentrated first on specific support measures, rather than broad based support measures, for in many cases the environmental effects per unit of subsidy removed will be larger in the first case.

In general, the removal of even relatively small subsidies to highly pollution intensive industries can be expected to be much more effective in terms of the amount of pollution reduced compared with the removal of broad subsidies which do not "hit" hard (*i.e.*, do not make a substantial cost difference). The importance of the sensitivity of a particular recipient sector to such cost differences leads to this conclusion. Several case studies have also shown that removing support to industrial consumers is more effective compared with the removal of support to households, due to the higher cost consciousness and the availability of alternative technologies for the former. Summarising:

removing subsidies to industrial consumers is much more effective in terms of reducing associated environmental damage than removing subsidies to households.

Another issue is the role of environmental policy. Sound environmental policies play a central role in improving the relative competitive position of environmentally benign technologies. Without such policies, the environment will be underpriced, providing too low price signals for the environmentally malign technologies to the recipient sectors who are deciding over different technologies. Therefore, support removal without appropriate pricing of the environmental effects of different energy sources might even prove harmful to the environment. Some case studies explicitly show that environmental policy and subsidy removal are synergistic. Thus, the fourth general conclusion is:

double dividends (fiscal benefits plus positive environmental effects) will be more likely from support removal if appropriate environmental policies are also implemented.

Closely related to this is the observation that support removal can trigger the removal of a whole set of institutional arrangements because, in order to protect particular industries, a whole package of related subsidies and regulations are often used. Therefore it is important to not only look at a particular subsidy or rule alone but also to look at the accompanying measures or the absence of such measures (*e.g.*, environmental restrictions).

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Effects of Government Subsidies on the Environment: the Case of Electricity and Newsprint Production from a Swedish Perspective

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EXECUTIVE SUMMARY

Many OECD Member countries offer various kinds of support to energy production, including the generation of electricity. The purpose of this study is to penetrate the environmental and economic effects of tax incentives to electricity production. In order to present empirical results for a real case, Swedish oil-condensing power plants have been chosen as the subject. This focus is of particular interest as power from these plants will often be the marginal source of electricity, and therefore will have an important impact on electricity prices. In the newly deregulated Norwegian and Swedish electricity markets, the short run marginal costs are key factors in price determination. This also means that the immediate impact of policy changes will often be realised through effects on these plants.

In order to analyse the downstream consequences of energy policies, the study looks at the effects on the energy-consuming newsprint producing industry, which is very important in the Swedish economy. Particular attention is given to how the policy would affect the choice between the use of recycled paper (DIP processes) and virgin pulp (TMP processes). When emissions at the input stage of electricity production are added to those in the paper production process itself, it turns out that use of the TMP process per tonne of newsprint generates higher emissions to the air than use of the DIP process. This is so for each of the three pollutants considered in the analysis: carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxides (NO_x).

The study considers a hypothetical policy option for the Swedish government and analyses the effects in Sweden while taking into account feedback effects from countries in the Nordic area and elsewhere in Europe. The policy parameters examined are the tax incentives provided by the exemptions and reductions in the CO_2 tax and the special electricity tax offered to particular industries in Sweden.

Most users of fossil fuels in Sweden have to pay a CO_2 tax of 0.36 SEK/kg CO_2 emitted. The manufacturing industry previously paid a reduced rate of 0.09 SEK/kg CO_2, which was raised to 0.18 SEK/kg from 1 July 1997. Even though this is still lower than for other sectors in Sweden, it is still much higher than the taxes for manufacturing industries in other countries. The electricity industry is exempt from the CO_2 tax. The manufacturing industry is also excluded from the special electricity tax, which is set at the rate of 0.13 SEK/kWh, and thereby benefits from low electricity costs compared to other electricity users in Sweden.

The specific question examined in this study is what the effects would be of making the domestic tax system neutral by applying the same CO_2 and electricity tax rates to electricity and newsprint producers as to other sectors. The effects of such a policy on newsprint production practices, via changes in input mixes and profits, are then examined. Following this, the effects on emissions of CO_2, SO_2 and NO_x to the air from reallocations in the production process are examined. This includes a number of international repercussions. The time perspective used is the medium term, *i.e.* around 5 years.

Cases reflecting different degrees of international competition

A quantitative analysis of the effects of subsidies on the environment is a complex issue and relies on large amounts of information where there is sometimes a great deal of uncertainty. In order to reasonably reflect these uncertainties, the present study analysed the effects under two different assumptions. The results of this technique highlight the strong interdependence between the electricity and paper producing industries – both in Sweden and in other countries.

The first case examined is highly hypothetical in relation to Sweden, in that it assumes that the production of electricity as well as pulp and paper is sheltered from international competition. This is a useful case to analyse, using Swedish data, because it clearly illustrates some of the basic economic costs of subsidies. The results may be of relevance to sheltered sectors which do exist in various economies. This is, however, a very unrealistic assumption for the Swedish paper industry, since it exports 80 per cent of its total production.

Under a policy of applying the same CO_2 and electricity tax rates to all users, it was found that the price of electricity would in this case increase from 0.25 to 0.47 SEK per kWh produced. This implies an increase in the marginal effective tax rate (METR) on electricity for industrial production from 25 to 135 per cent. The METR indicates the incentive effects of government policies on the composition of inputs and production volumes. It is calculated in two steps, where the first is to determine the difference between the electricity price when policy measures are implemented and the price without policy intervention. The second step is to express this tax wedge as a percentage of the "intervention free" price of electricity. In this case, the large increase in the METR under the policy indicates a strong incentive to economise on electricity usage.

In the absence of international competition, these increased costs in paper production will, to a high degree, be shifted forwards into higher newsprint prices. Given the low elasticity of demand for newsprint, demand would be expected to fall only slightly as a result, implying only a small decline in emissions. There would be no international feedback effects in terms of changes in the flows of emissions to and from other countries in this case, because of the assumption of a sheltered economy.

In the second case examined, the assumptions have been designed to reflect current realities for Sweden and its paper and electricity industries as closely as possible. The electricity market is regarded as a fully integrated Swedish, Norwegian, Finnish and Danish market, which will probably be the case within the next five years. Electricity prices in countries outside this market are assumed to be unaffected by the policy change. It is also assumed that the CO_2 tax and the special electricity tax are only applied to the Swedish newsprint producers. Competitors in other countries will, therefore, obtain a competitive advantage from the taxes.

In this case, the increase of the METR would also be high, though not as significant as in the first scenario. The cost increase would have strong structural effects, since international competitiveness of the Swedish newsprint industry would fall dramatically, despite a more limited electricity price increase from 0.25 to 0.38 SEK/kWh. Imports of electricity from coal- and oil-condensing power stations in Denmark and Finland would effectively hold down this price increase. There would be a big decrease in Swedish newsprint production and, therefore, of emissions to the area in and around Sweden. The emissions would move with the production to other countries that produce for the world market.

The rest of this summary will concentrate on this second, more realistic, open economy case.

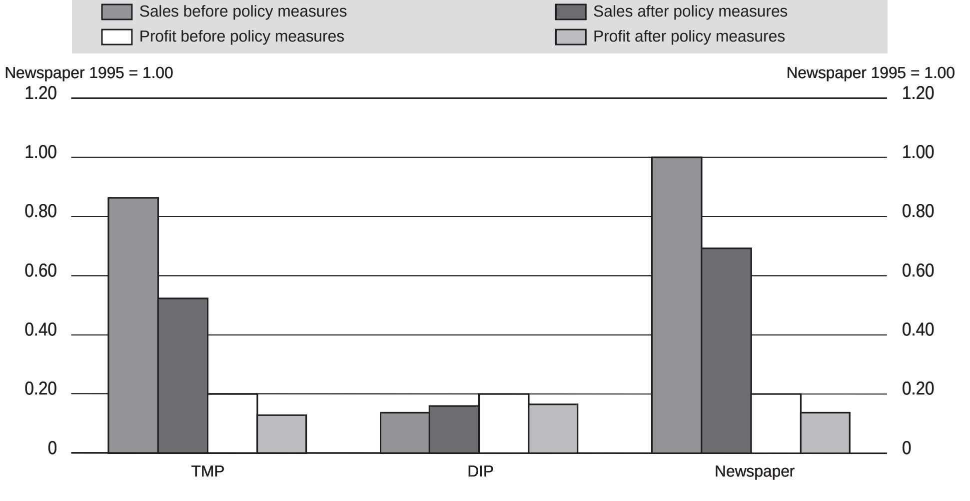
The decisive factors behind the effects

The increase in electricity and oil prices that would result from removing the CO_2 and electricity tax exemptions to Swedish industries would lead to some substitution between different fuels in the production process. The extent to which this would happen will depend on the size of the own-price and cross-price elasticities. In production based on virgin fibre (TMP), such cost-reducing substitutions would not prevent a major fall in the gross profit margin from the base level of 20 per cent of turnover down to around 13 per cent. In plants using the less electricity-intensive process based on recycled paper (DIP), the profit margin would fall by around 3 percentage points. Contributing to this less dramatic change is the possibility in this case of substitution from oil to biofuel, which is not an option in the TMP process. As a reaction to reduced profit levels, production in Swedish establishments would go down.

The analysis is based on estimates of the elasticities of sales with respect to changes in profit levels. By experience, these elasticities are fairly high for industries under pressure from foreign competitors. The estimated effects on production are illustrated in Figure 1, showing a strong decline in TMP production and a slight increase in DIP. The increase in DIP is explained by the possibility that DIPbased production can replace TMP using existing paper machines, harbours and other infrastructure. Overall, the production of newsprint in Sweden is estimated to fall by more than 30 per cent as a result of the policy measures. Most of this reduction would be replaced by production in other EU countries, where advantages may be explored such as good access to recyclable paper, low transport costs and the availability of gas which provides favourable conditions for combined heat and power production (CHP).

As a consequence of the various factor substitutions involved and the changed proportions of TMP and DIP in total production, the inputs of different kinds of energy per tonne of paper produced would also change. These changes are shown

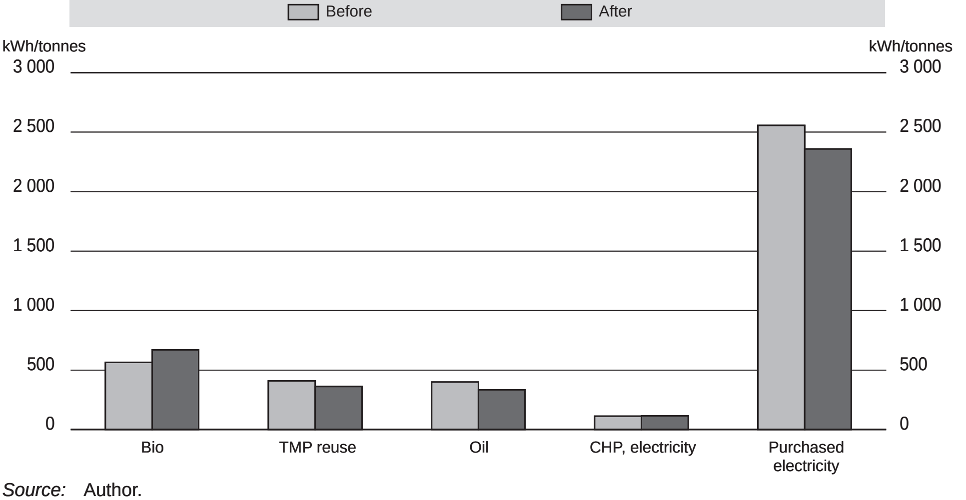
Figure 1. **Sales and profits before and after policy measures**



Source: Author.

in Figure 2. Together with changes in the production level, these will determine any effects the policy will have on the pollution emission levels. As can be seen, the use of biofuels in the new production mix will increase, whereas the use of electricity and oil will fall. The reduced production share of TMP will also mean that reuse of heat in the TMP production process will go down. Most importantly for the results of this study, the electricity requirements in the DIP process is much less than in the TMP process.

Figure 2. **Specific energy use for the particular mix of TMP and DIP production processes used in Sweden before and after policy changes**



Source: Author.

The policies under study would thus lead to significant effects on the structure and level of newsprint production in Sweden. Clearly these would reduce emissions within Sweden. The reduced demand for electricity would have some particularly important effects since, on the margin, Sweden is dependent on electricity imports from old power plants in neighbouring countries. These plants have fairly high emission rates. For this reason, reduced newsprint production in Sweden would be expected to lead to significantly lower emissions to the air. On the other hand, because paper production will then be increased in other countries to compensate for the shortfall on the world market for newsprint, emissions could be expected to increase in those countries.

Two scenarios are considered in estimating the changes to foreign emissions: one which assumes low emission rates for electricity and newsprint production in the countries increasing paper production, and one which assumes high emission rates. In addition, for the low emission scenario an assumption of a slight reduction in world demand for newsprint is combined with a high proportion of DIP production replacing the reduced TMP production in Sweden. The high emission scenario assumes unchanged world demand for newsprint and a smaller substitution of DIP for TMP.

This approach of modelling two different emission scenarios was used due to incomplete information on emission rates, electricity supply systems and production techniques in some foreign countries. The two sets of assumptions, explained in detail in the case study, are constructed as variations around what has been taken as reasonably realistic base assumptions. Results of the calculations are presented in Table 1.

Table 1. **Overall changes in emissions in Sweden and elsewhere**

Tonnes for SO_2 and NO_x; thousands of tonnes for CO_2

	CO_2	SO_2	NO_x
	High emission scenario		
Sweden	–1 810	–4 670	–4 110
Other countries	1 640	5 870	5 240
Total	**–170**	**1 200**	**1 130**
	Low emission scenario		
Sweden	–1 810	–4 670	–4 110
Other countries	600	1 020	1 080
Total	**–1 200**	**–3 640**	**–3 030**

Under the assumptions used, the positive effects of emission reductions in Sweden are big enough in the low emission scenario that they significantly outweigh the increased emissions in other countries. However, in the high emission scenario, the global emissions for SO_2 and NO_x would actually increase because the decline in these emissions in Sweden would be smaller than their increase in other countries.

Reservations to the results

Obviously the analysis and the quantitative results are not telling the full truth about the issues raised. As always, when one goes beyond a pure theoretical approach and tries to see how things work in the real world, complications arise, not least because of the shortage and unreliability of empirical data and uncertainty about the magnitude of response mechanisms. Therefore, the work presented in this study should be seen as an empirical illustration to theories of how government policy measures affect the environment. In doing this, it also demonstrates the difficulties of attempting to accurately predict the effects of such government policies.

In accordance with economic theory, the study has taken a marginal approach in the analysis. This means, for example, that the focus is on emissions from marginal units of electricity supply, not on average emissions. In the case of Sweden, average emissions to the air from electricity generation are very low due to the dominance of hydro and nuclear power plants, but also because of very strict environment standards on the marginal power stations (mostly oil-condensing power). Emissions on the margin can still, however, be quite high since the last production units in operation in the integrated Nordic electricity market are usually from coal- or oil-fired power plants in neighbouring countries with less strict environmental standards on peak load power stations.

Although it is necessary to look at production and emission effects on the margin in order to predict the consequences of changes in prices due to policy measures, it also makes the empirical analysis much more complicated. Official statistics on electricity generation, pollution emissions, cost shares in paper-production and other relevant variables are based on totals or averages, not on observations on the margin.

Adjustment costs to a new equilibrium

In an economy where electricity generation and paper production are sheltered from international competition, or in a large economy with limited foreign trade, a reduction in subsidies would be likely to have a rather small, although not negligible, effect on production and therefore on the environment. This is because the bulk of the cost increase could be passed on to newsprint consumers in terms of higher prices. Because of the low price elasticity of demand for newsprint, it is unlikely that newsprint consumption would decrease significantly in response to such a price rise.

In a small, open economy on the other hand, the effects of such a policy could have a dramatic impact on production and emissions in that country. Industrial companies aim to make a reasonable profit given an internationally-set market price for a commodity. If profit targets are not satisfied in one country, production will simply move to other parts of the world where production costs are lower. Such mobility implies that isolated measures that increase costs in one country will generate important structural effects on the industry and the economy in that country. Subsidies or tax incentives to an industry can therefore have major effects on the flow of resources into that country and will, of course, harm similar industries in other countries. Thus, it would be expected that removing the tax exemptions in Sweden would lead to a loss of competitiveness to the Swedish pulp and paper industries and a shift of their operations to other countries.

Even though industrial companies in Sweden pay lower electricity taxes than other domestic groups, they still pay much higher CO_2 and SO_2 taxes than most of their competitors in other countries. It is clear that, for Sweden, an environmental policy of the kind discussed in this study would lead to a significant negative impact both on employment in rural areas and on the balance of payments. In the longer run, the effects might be less harmful due to adjustments in technology and market reallocations. But, as shown, whether the net effect on global emissions of such a policy would be positive or negative is difficult to establish with confidence.

Policy conclusions

Under one set of assumptions applied in this study, reduced support – or higher taxes – to electricity generation and newsprint production in order to make the Swedish tax system more neutral would result in a decline in emissions and reduced pollution in Sweden. On the surface this looks like the kind of policy that from a government point of view would generate a win-win outcome, in that it would combine a positive environmental effect with a gain in public sector revenue.

Reflections on the structural effects on the economy of this kind of policy, however, indicate that the overall costs, at least in the short to medium term, could be very much higher than for other policies to achieve the same results. The potential environmental gains are also highly uncertain because of the shift in the environmental burden to other countries. In the high emission scenario, the global emissions would be expected to increase for two of the three pollutants.

All in all, this indicates that incremental, steady and predictable changes in the policies might be advisable in this and other fields, especially in small countries that are highly dependent on international trade. The study also indicates the difficulties of deviating from policies that exist in competing countries.

There is clearly an urgent need for better knowledge about the costs to society of these polluting emissions. The very few studies that are available[1] indicate that the costs of climate change (the greenhouse effect) are about 1-9 öre per kilogram CO_2 emitted, *i.e.* lower than the taxes paid by Swedish industry and much lower than the taxes levied on households and other groups in Sweden (18 and 26 öre per kilogram CO_2 respectively). This and other information referred to later in the report indicates that the current target levels for the taxes under examination may be too high. This could mean that there would be net welfare losses from the policy in the long run, as the tax would be over-compensating for a market failure rather than optimising efficiency.

An implication of the analysis is that important advantages could be achieved if countries acted together in their environmental policies, for instance by co-ordinating tax and subsidy policies. This would have a particularly relevant bearing on climate change because it is a truly global problem. In this way, the problems associated with dramatic changes to the production levels in individual countries could also be avoided.

The study illustrates that a solid basis for a properly designed environmental policy requires a great deal of information on conditions beyond the national border, as well as within the country. This includes knowledge of the relevant policy systems (including regulations), production methods, substitution possibilities, marginal energy suppliers and pollution emission rates. Without such information, it will be impossible to estimate whether the total environmental effects of changes in subsidy or tax policies are worth the cost that may have to be paid in other dimensions.

1. INTRODUCTION

1.1. Background and aim of this study

Many OECD Member countries use a range of policy instruments in connection with their electricity sectors. These support measures, regulations and taxes not only impact on the sector itself, but also affect industries that are dependent on electricity as a production factor. This case study, which was undertaken as part of the OECD project on the effects of economic support measures on the environment, will illustrate this by looking at the inter-relationship between electricity generation and newsprint production in Sweden.

Often when the effects of one type of government intervention are analysed, it is found that other government interventions are also important. This is very true for the electricity producing sector where subsidies, tax incentives and regulations interact in a complex way. Paradoxically, on the political scene, subsidies are sometimes motivated by high price levels or price increases that are caused by the presence of taxes and regulations. Thus, to keep a competitive electricity-intensive industry in a country with generally high taxes, the government may feel it has to reduce the price effect of these taxes through subsidies.

This case study aims to illustrate the ways in which different types of government subsidies, taxes and regulations affect the electricity price, and how this will impact on the composition of electricity consumption and on the production methods used by the newsprint producing industry. The focus is on the newsprint industry in Sweden and other Nordic countries.

The main preferential treatment or "subsidy" examined is that neither the power industry nor the pulp and paper industry pays the energy tax which other sectors are obliged to pay in Sweden. These sectors are also given preferential treatment with regard to the CO_2 tax.

1.2. What should be regarded as a subsidy?

From an economic point of view, all activities that do not pay their full environmental costs can be regarded as subsidised. This is a good starting point for any analysis of government subsidies and environmental costs. However, a practical problem with this definition is, of course, the difficulties inherent in calculating the actual size of many environmental costs. The scientific grounds for implementing a particular environmental tax level are often weak, and taxes that are put forward as environmental taxes are often partly motivated by financial or other objectives besides an attempt to internalise the full external costs of the activity.

When the industrial sector benefits from lower tax rates than service and household sectors within a country, but these taxes on industry are roughly equivalent to, or even higher than, that on foreign competitors, is the industry subsidised or not? Clearly, the international aspects concerning the effect of the subsidy on trade and the environment will have a big impact on the analysis. Pollution is often an international (and sometimes a global) problem, and businesses who have to pay "green" taxes in one country may move production across borders to where the taxation system is most favourable.

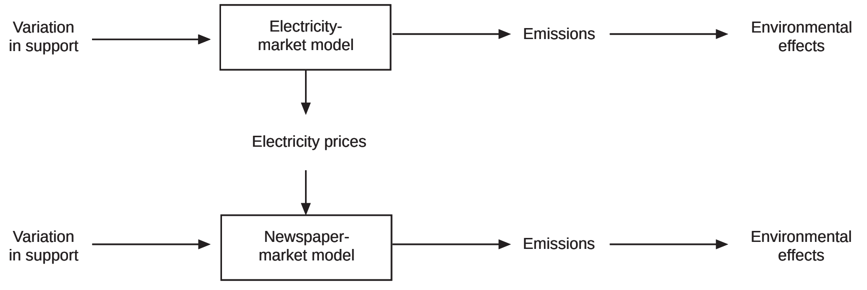
1.3. Scope and method of analysis

To enable calculations of the environmental effects of subsidies and tax incentives to electricity generation and newsprint production, this study has made use of a simplifying empirical model. This is neither an econometrically-estimated model nor a computable general equilibrium model. It could be described instead as a fairly mechanical framework encompassing state descriptions of the sectors under study, price and production elasticities and marginal response vectors in terms of emissions and pollution. The model is used as a tool to co-ordinate all the necessary information and to facilitate trial and error calculations and simulations. The results generated by the model were at all levels cross checked by expert knowledge from within the field.

Support measures under study

The support measures studied, in this case tax incentives, were the differentiations in the CO_2 tax and the electricity-specific tax. Most users of fossil fuels in Sweden have to pay SEK 0.36 per kilogram of CO_2 emitted. The manufacturing industry used to pay a reduced rate of SEK 0.09 per kilogram CO_2, which was raised

Figure 1.1. **Overview of the analytical framework**



Source: Author.

to 0.18 SEK as of 1 July 1997. The electricity industry is exempt from the CO_2 tax. Because the manufacturing industry is excluded from the special electricity tax, which is applied at the rate of SEK 0.13 per kWh for other users, it benefits from lower electricity costs than other electricity users in Sweden.

The fact that the manufacturing industry and electric power generation are faced with lower tax rates than households and the service sector with regard to these taxes may be interpreted as the existence of a subsidy through preferential tax treatment. However, it is also true that the energy and environmental taxes that are applied to the manufacturing industry and power generation in Sweden are already higher than in most other countries where competitors are located. So this could also be interpreted as over-taxation of these sectors in Sweden.

These conditions apply to the Swedish manufacturing industry in general, of which the newsprint industry is just one part. In order to carry out the analysis with the required detail, it was necessary to limit the scope of this study to a specific sector. The newsprint industry was chosen because it has some features that are of particular interest in the present context: it is relatively electricity intensive, it operates on an international market, and it has the option of producing its product in two different ways, with very different electricity requirements associated with each.

Clearly, it is illogical to argue at the same time that Swedish industry is subsidised and excessively taxed. Chapters 1-6 of this study are developed under the hypothesis that the subsidy view is the more relevant. This is done for pedagogical reasons in order to avoid confusing the reader with too many side-tracks in the analysis. In Chapters 7-8, the subsidy view is challenged when the realities of the international interdependence of a small, open economy and the international nature of environmental problems are fully considered.

Environment effects

Electricity generation and newsprint production give rise to a number of environmental effects, including emissions to air, water and ground systems. This study concentrates on air pollution, particularly in terms of sulphur, nitrogen and carbon dioxide. Other environmental problems, such as emissions to water or disposal issues, are not covered.

The electricity market model

The electricity market model analyses the effects of the policy on the marginal production costs for electricity generation. Even though most of the electricity generated in Sweden comes from hydro and nuclear power plants, it will almost always be the plants based on fossil fuels (the marginal supply) that determine the price. These are generally either oil-condensing power plants in the Nordic countries or coal-condensing plants in Finland and Denmark. The focus of the study is therefore on the running costs and environmental effects of these plants. These aspects are accounted for in detail in the model.

The newsprint market model

An important feature of the model of the newsprint market is the possibility of substitution between newsprint made from virgin fibre and from recycled newsprint (TMP and DIP processes respectively). Another important feature is the analysis of the potential substitution possibilities between electricity, fossil fuel, biofuel and capital within each process. Finally, Sweden's market share of newsprint production in the different scenarios is subjected to analysis. For this, a set of price elasticities is applied.

To calculate the environmental effects of newsprint production, a hypothetical model factory has been designed. This hypothetical factory is used to balance the fact that the newsprint factories in Sweden all use slightly different technologies. The construction of this model was facilitated by information provided by representatives of the pulp and paper industry.

The scenarios

Any analysis of the effects of subsidies on the environment will necessarily be complex. Therefore, this report takes a stepwise approach in analysing first a closed economy case before then continuing with a more realistic open economy case. The analysis will require large amounts of information, about which there is sometimes a great deal of uncertainty. In order to reasonably reflect these uncertainties, the present study analyses the effects of the policy under two different scenarios regarding the possible production and emission responses at the international level to the policy changes in Sweden. These are presented as low and high emission scenarios respectively. The time perspective applied is the medium term, *i.e.*, examining effects for around 5 years into the future.

1.4. Brief overview of the tax/subsidy system

Taxes on the energy sector

Electrical energy is taxed both when it is produced and when it is consumed. The tax paid by consumers differs between the northern part and the rest of Sweden and across different consumer groups (Table 1.1), reflecting differences in climate and equity concerns. Certain consumers, *e.g.* households and public administration, also pay value added tax at a rate of 25 per cent on the electricity price including the energy tax.

Table 1.1. **Taxes on electricity consumption in Sweden, 1 January 1997**

	Northern Sweden, SEK/kWh	Rest of Sweden, SEK/kWh
District heating utilities	0.053	0.091
Industrial users	0	0
Other users	0.053	0.113

All fuels that are used for electricity production are exempt from energy and carbon dioxide taxes, but the sulphur tax and nitrogen oxide charges are levied. Table 1.2 below compares the energy tax on electricity generation, hot water production, the manufacturing industry, and on other consumers.

For the sake of completeness, Table 1.3 provides information on the special tax treatment of other sources of electricity generation.

Subsidies to electricity generation

There are basically two types of electricity generation that receive direct state subsidies in Sweden: biofuel fired combined heat and power plants (CHP) and wind power. The support to the CHP plants is approximately 20 per cent of the investment costs, although in some cases the support has been as high as 40 per cent. The support to wind power is 15 per cent of the investment costs as of 1 July 1997. The owners of wind power also receive an environmental bonus of 0.138 SEK/kWh.[2] Finally, there is some minor support to small scale hydro-power plants.

Table 1.2. **Swedish taxes on fuels used in electricity production, district heating, the manufacturing industry and by other users, 1 January 1997**

	Electricity generation	District heating	Industry	Other users
Energy tax	Exempt	654 SEK/m^3 fuel oil*	Exempt	654 SEK/m^3 fuel oil
CO_2 tax	Exempt	0.36 SEK/kg CO_2	0.09 SEK/kg CO_2	0.36 SEK/kg CO_2
Sulphur tax on peat, coal and oil firing (if the emissions are measured)	30 SEK/kg sulphur emitted	As for electricity generation	As for electricity generation	As for electricity generation
Sulphur tax on oil (if the emissions are not measured)	27 SEK/m^3 per every tenth per cent by weight of the sulphur content in the fuel oil (only if sulphur content exceeds 0.1% by weight)	As for electricity generation	As for electricity generation	As for electricity generation
Nitrogen charge	40 SEK/kg nitrogen oxides emitted	As for electricity generation	As for electricity generation	As for electricity generation

* For coal, the energy tax is 278 SEK/tonne and for natural gas it is 212 SEK/1 000 m^3.

Table 1.3. **Taxes applied to other sources of Swedish electricity generation, 1 January 1997**

Nuclear power tax	0.0435 SEK/kWh*
Property tax on hydropower	Property tax 3.425% on the land and equipment value (approximately 3 öre/kWh)

* Including 0.02 SEK/kWh for financing future expenditures on nuclear fuel waste.

The manufacturing companies

The energy taxes on Swedish manufacturing companies, including newsprint producers, are accounted for in Tables 1.2 and 1.3. In addition, they are charged with a tax on company profit at the rate of 28 per cent, which is rather low by international comparison. On the other hand, the overall rate of employer social security contributions, 32.9 per cent, is relatively high.

2. THE ELECTRICITY SYSTEM

2.1. The electricity market

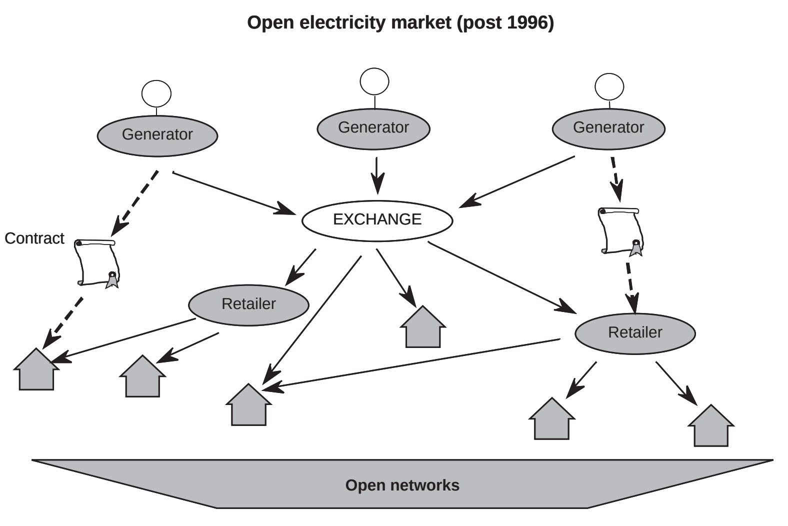
In January 1996 a major electricity market reform was undertaken in Sweden (see Figure 2.1). The guiding principle was to introduce competition where possible. This resulted in a sharp division between electricity:

– generation and sales;

– transportation services (networks); and

– system services (frequency control, accounting, settlement).

Figure 2.1. **The new electricity market**



Source : Author.

Electricity generation and sales is undertaken in a competitive environment. The retailer and the end consumers are free to buy electricity from a range of suppliers (but not the electricity distribution service) and the power companies are free to choose their customers.[3] To reduce the trading costs, a power exchange was established. This offers trade in physical quantities to be delivered the next day (spot) and financial contracts (futures) for the handling of risk. The power-exchange is common for Sweden and Norway.

The transportation services are more strictly regulated than before 1996. companies that operate electrical networks are not allowed to operate power plants or to engage in electricity trade. The owner of the national grid in Sweden, a state agency (Svenska Kraftnät), is responsible for the system services.

There is basically the same electricity legislation in Norway and in Finland. In a couple of years these markets will probably be fully integrated. Denmark is also in some respects part of this common market, as the Danish power companies are free to compete in the Nordic market. The Danish home market is, however, still closed to power companies from the other Nordic countries.

2.2. Electricity Generation in Sweden

Electricity generation in Sweden is very much dependent on hydro (normally 63 TWh) and nuclear power (70 TWh). The actual production capacity of hydro power varies with the precipitation rates. In dry years the production can go down to below 50 TWh per year, while rainy years can result in up to 80 TWh.

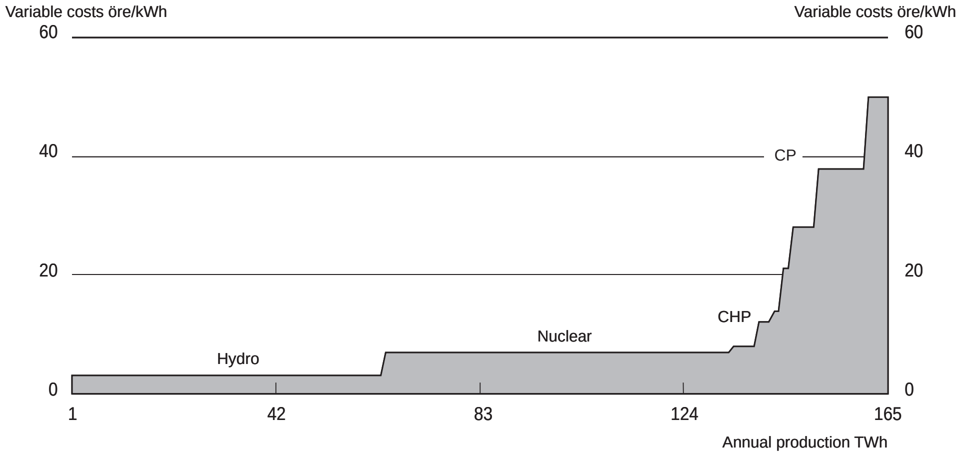
Another source of electricity supply is the combined heat and power (CHP) capacity. The yearly production varies between 3 and 6 TWh, depending on how cold the winters are and on the spot-prices for electricity. Industrial back-pressure can produce almost 5 TWh in a year with high spot-prices. This capacity is mostly based in the pulp and paper industry, primarily in the production of chemical pulp but also to a certain extent in the production of mechanical pulp (TMP) that can be used in newsprint production.

Over and above this capacity there is important reserve capacity in the system. This consists mainly of oil-condensing power stations (OCP) with a power of 3 000 MW and a yearly energy capacity of about 17 TWh. There is also almost 2 000 MW of gas-turbine capacity which can produce about 5 TWh per year. Finally, there is one coal-condensing power plant which can be set to produce electricity only during periods of low demand for district heating (coal-condensing tales). The yearly production capacity is around 1 TWh.

The variable costs of the systems vary from about 0.01 SEK/kWh for hydro-power to about 0.5 SEK/kWh for gas-turbines (Figure 2.2). The reserve capacity plants are used during dry years when hydro production is low, in cold periods during the winter with high electricity demand and when other power plants or the net suddenly falls out.

The parliament has decided that one nuclear reactor of 600 MW will be phased out on 1 July 1998. Under the condition that enough power from alternative sources can be supplied, an additional nuclear reactor of 600 MW will be phased out in the year 2001. This, combined with the predicted increase in demand, will probably increase the use of oil-fired power plants in the following years.

Figure 2.2. **Electricity generation capacity and their variable costs, Sweden**



The total electricity demand in Sweden is currently around 135 TWh per year. The pulp and paper industry by itself accounts for almost 20 per cent of the total consumption, and newsprint production for 5.5 TWh.

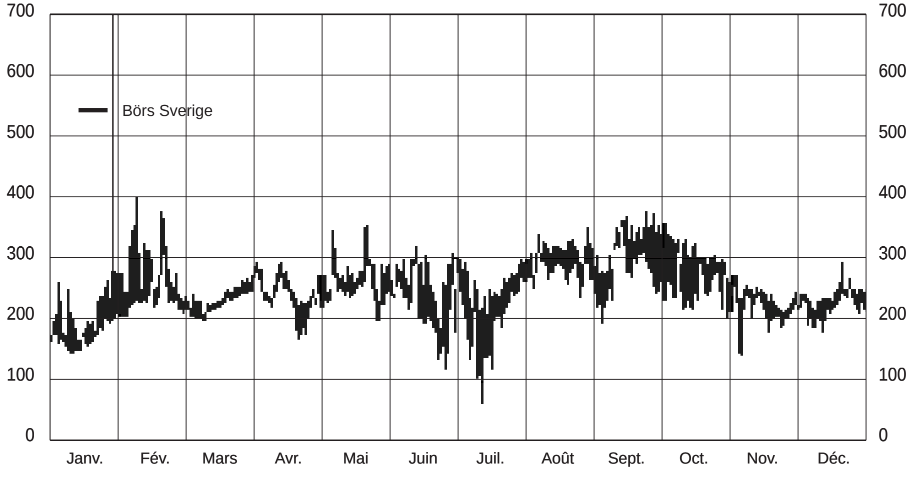
2.3. The price mechanism

The Swedish electricity system has been, and still is, run under a principle of merit order. The power plants that are needed at any given time are chosen in order to use the lowest-cost plants first. This is accomplished without central orders, simply because the different power companies optimise their production (*i.e.*, maximise their profits) according to the spot-prices on the market. The spot-prices have, so far, accurately reflected the marginal production costs (SRMC), usually the variable costs of the most expensive power plant in operation at any one time (see Figure 2.3).

Since 1996 was a rather dry year, Swedish oil-condensing power was in use during a large part of the year. Even though the oil-fired power plants provided a rather limited proportion of the total production, they were very important for the movements of the spot-price.

Since the price level in all long-term contracts reflects the expected spot-price level during the contract period, the price of Swedish oil-condensing power will be more and more influential in determining the price Swedish consumers have to pay

Figure 2.3. **Prix spot de l'électricité en 1996, SEK/MWh**



for electricity. This is because the oil-condensing power is expected to be used more in the future due to a reduction in the nuclear capacity and an increase in the demand for electricity.

2.4. Government framework for oil-condensing power stations

There are three different regulatory frameworks in the Swedish environmental legislation that affect the costs of fossil and biomass-based power stations. These are:

- the energy production act with an environmental fee on the emission of nitrogen oxides;
- the sulphur act; and
- the environment protection act.

The energy production act

This act covers energy production plants that produce more than 25 GWh of useful energy annually. It applies a charge of 40 SEK per kg NO_x emitted. The charge is transferred back, according to the amount of energy produced, to those who were liable to pay the charge. The amount of emitted nitrogen oxides is measured using relatively expensive equipment, amounting to SEK 300 000 or higher per plant.

Example

Suppose an oil-condensing power plant has NO_x emissions of 70 mg/MJ of energy used (about 0.25 kg NO_x/MWh). For every kWh of energy used, the power plant produces 0.4 kWh electricity. This means that the company pays 2.5 öre/kWh for electricity generated (= 0.25*40/0.4).

The payback to those liable to pay the charge in 1995 was 1.1 öre/kWh useful energy produced.

The net nitrogen emission fee in this example is, therefore, approximately 1.4 öre/kWh electricity produced.

The sulphur act

The sulphur act regulates the emission of sulphur from combustion. The maximum level of emissions allowed is 100 mg/MJ of fuel used. If the total emissions from one production plant are higher than 400 tons of sulphur annually, the maximum emissions allowed is reduced to 50 mg/MJ of fuel used. Normal sulphur content in heavy oil on the world market is about 3.5 per cent, or around 900 mg/MJ oil. The heavy oil that is sold in Sweden usually has a sulphur content of 0.35 per cent, or approximately 100 mg/MJ.

Large combustion plants, like for example Stenungsund's oil-fired power plant, will soon reach emission levels of over 400 tons of sulphur annually. Without special desulphurisation equipment, the company will have to use light oil with a sulphur content of less than 0.1 per cent sulphur. There are also some limited quantities of heavy oil with a sulphur content of 0.2 per cent available on the world market that could be used.

All power generating companies also pay a sulphur tax at a rate of SEK 30 per kilogram of sulphur emitted.[4] For a power plant based on oil with a sulphur content of 0.4 per cent, the sulphur tax is approximately SEK 0.027 per kWh electricity produced. Only one oil-condensing power station has invested in desulphurisation equipment so far.

The environmental act

According to the environmental act, all combustion plants larger than 10 MW of installed capacity must have a permit to operate. Larger plants (200 MW and above) obtain their licenses from a special committee, while smaller plants get their licenses from the county administrations.

A permit gives the owner the right to build and operate the plant under certain conditions. This part of the legislation is rather loosely defined. All measures that are technically possible and economically reasonable should be taken. These conditions can be reviewed every tenth year. The conditions concerning emission of sulphur and nitrogen are designed as guidelines or limits, whose violation can result in prosecution.

The different power stations have specific conditions attached to their permits. Sometimes this is because the permit was granted many years ago and sometimes it is because what is technically possible differs between sites. The differences may also depend on the use of different assessment criteria by the different regulatory bodies (koncessionsnämnderna).

Effects on production costs – a summary

The Swedish environmental legislation imposes heavy demands on oil-fired power plants. There are also large differences in legislative requirements between the plants. Despite the high environmental standards, the power companies have chosen not to make large investments in cleaning devices. Instead, they have chosen to make less expensive technical changes in the combustion process and to rely on oil with extremely low sulphur content. The only exception is Sydkraft, which has invested in desulphurisation equipment in one of the blocks of the Karlshamn power plant. This block and one more are also equipped with catalytic cleaning devices to reduce the emission of nitrogen oxides.

Based on earlier work, an effort has been made to estimate the effects of the environmental regulations on the variable production costs of the oil-fired power plants. As already indicated, this is equivalent to the effect on the marginal cost of electricity production wherever these plants are on the margin.

The assumptions made regarding the prices of different qualities of oil are shown in Table 2.1. Table 2.2 reports the results of the calculations.

Table 2.1. **Oil price assumptions, September 1996**

Sulphur content	Price $/ton	Price SEK/kWh
0.1	250	0.140
0.2	190	0.109
0.3	160	0.092
0.4	145	0.083
0.5	120	0.069

* The exchange rate SEK/dollar is assumed to be 6.65.

Table 2.2. **The effect government measures have on variable costs in Swedish oil-based power plants**

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
	Capacity MW	Base price[a] SEK/kWh	Low sulphur oil SEK/kWh	Nitrogen fee SEK/kWh	Sulphur tax SEK/kWh	Other[b] SEK/kWh	Total variable cost SEK/kWh
Karlshamn	< 335 MW	0.172	0	0.002	0.003	0.030	0.207
	335-450 MW	0.172	0.100	0.002	0.013	0.01	0.298
	> 459 MW	0.172	0.177	0.002	0.0	0.01	0.362
	> 670 MW	0.168	0.173	0.038	0.0	0.0	0.379
Stenungsund		0.181	0.187	0.008	0.0	0.0	0.376
Aroskraft		0.179	0.06	0.003	0.021	0.01	0.272
Stockholm Värtan		0.179	0.184	0.016	0.0	0.0	0.379
Stockholm Hässelby		0.179	0.06	0.012	0.021	0.01	0.281
Bråvalla		0.176	0.059	0.026	0.021	0.0	0.282
Marviken		0.197	0.115	0.032	0.015	0.0	0.359

a) The base-price is the variable production cost with a burning oil with 3.5% sulphur and without environmental taxes.
b) Other costs are, for example, additives used to separate nitrogen oxides.
Source: Own estimates.

In Table 2.2, the cost increase that arises from using low sulphur oil (column 4) is directly related to government regulations about the sulphur content of fuel. The cost increases in columns 5 and 6, however, are related to taxes and fees. This is not entirely true because, without the quantitative restrictions, the power plants would probably have generated higher emissions and therefore paid higher nitrogen fees and sulphur taxes.

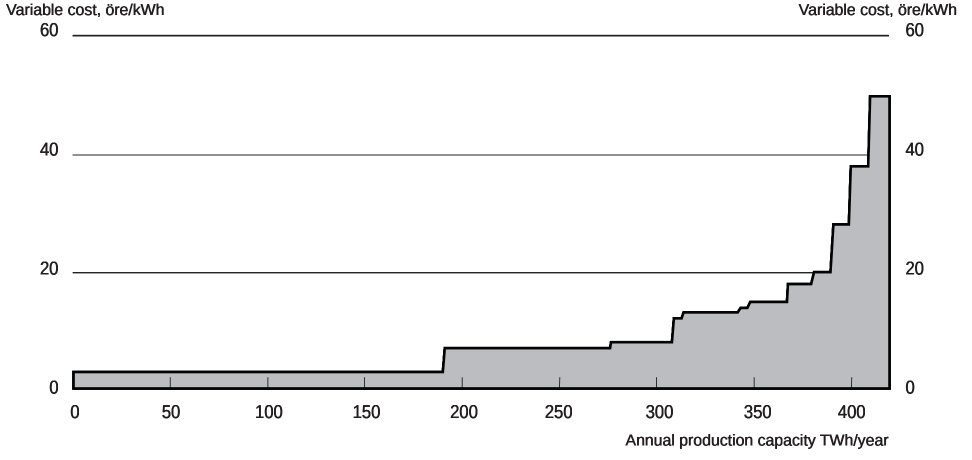
The difference between the total variable cost in column 8 and the base price in column 3 represents the tax wedge on these plants. As can be seen, this varies from 0.035 SEK/kWh to 0.20 SEK/kWh. These wedges can also be expressed as Marginal Effective Tax Rates (METRs) of 20 and 120 per cent of the respective base prices.

An estimate has been made of which oil quality would need to be used to minimise the variable costs, given the current oil prices and the existing taxes. These calculations indicate that a burning oil with 0.4 per cent sulphur would be chosen. The total tax would probably be around 0.04-0.05 SEK/kWh, which would give a total variable cost of approximately 0.25 SEK/kWh.

2.5. The Nordic electricity market

As mentioned earlier, the three countries of Finland, Norway and Sweden pretty much share a common electricity market. In the figure below, even Denmark

Figure 2.4. **Electricity generation capacity in the Nordic countries and variable costs**



Source: Author.

is included in the supply function. This is because Danish power companies have open access to the rest of the Nordic market and, therefore, influence the spot-price as if they had the same legislation as the other three countries. The total demand in the four countries is approximately 335 TWh per year.

Around 45 per cent of the generation capacity is hydropower with low variable costs but, as mentioned before, with big variations in supply due to weather conditions. About 20 per cent is nuclear power and 10 per cent combined heat and power. Coal-, peat-, gas- and oil-fired condensing power stations have an annual production capacity of around 85 TWh (20 per cent) altogether. The variable costs of these plants varies between SEK 0.13 and 0.40 per kWh with very important effects on the market price level depending which is the marginal source.

Environmental restrictions on electricity generation in Denmark and Finland

Denmark

In Denmark there are total emission quotas for the whole country. Total emissions from electricity generation must not exceed 180 000 tons SO_2 and 85 000 tons NO_x. By the year 2000, these levels should be only 55 000 tons SO_2 and 60 000 tons NO_x. These figures refer to domestically-generated electricity for internal use only. Exports and imports are excluded.

There are no other restrictions on the power companies nor any emission taxes to be paid. In the consumer stage, there is a tax levied at DKR 0.10 per kWh. The power plants that are used to generate electricity for exporting to Sweden and Norway usually lack cleaning devices for SO_2 and NO_x. These plants usually use a burning oil with a sulphur content of 1 per cent. Without desulphurisation equipment this leads to emissions at a level of approximately 250 mg/MJ added fuel. The emissions of NO_x from these plants is at the level of 350-450 mg/MJ added fuel.

Finland

In Finland there are quantitative restrictions on both new and old power plants (Table 2.3). These are usually general, unlike in Sweden where they are unique for each plant, but local authorities can be more restrictive in certain cases. There are no taxes on electricity generation in Finland.

Table 2.3. **Emission limits on Finnish coal- and oil-fired power stations**

	SO_2	NO_x
New coal CP > 150 MW	140 mg SO_2/MJ coal	50 mg/MJ coal
New coal CP 50-150 MW	230 mg SO_2/MJ coal	150 mg/MJ coal
Old coal CP > 200 MW	230 mg SO_2/MJ coal	230 mg/MJ coal
Smaller CCP	No limits	> 100 MW 230 mg/MJ coal
New oil CP > 300 MW	1% S in fuel = 500 mg SO_2/MJ	50 mg/MJ oil
New oil CP 150-300 MW	1% S in fuel = 500 mg SO_2/MJ	80 mg/MJ oil
New oil CP 50-150 MW	1% S in fuel = 500 mg SO_2/MJ	120 mg/MJ oil
Old oil CP > 100	1% S in fuel = 500 mg SO_2/MJ	120 mg/MJ oil
Smaller OCP	1% S in fuel = 500 mg SO_2/MJ	No limits
Gas turbines	1% S in fuel = 500 mg SO_2/MJ	No limits

Source: Finergy.

Norway

Since Norwegian electricity production is almost entirely based on hydropower, there is no air-borne emissions problem to regulate.

2.6. Electricity prices in the closed/open economy cases

The electricity market model[5] was used to estimate the electricity prices in the two cases. This model minimises the production costs in the Nordic electricity market given the generation capacities, the variable production costs, the transmission constraints and the demand in each area. Except for interruptible electric boilers, the demand is decided exogenously.

The price level is estimated as an average for the coming five years. During that period, one or perhaps two nuclear power stations in Sweden will be closed as a result of political decisions. The variable production costs are defined to include the variable net tariff that generators pay when they feed power into the market.

Table 2.4 shows the assumptions used for Case 1, which assumes the Swedish electricity market is sheltered, and includes estimates of the Marginal Effective Tax Rates (METRs). The METR is calculated as the difference between the short run marginal costs (SRMC) in electricity generation with and without energy related policy measures divided by the SRMC without policy measures.

Table 2.4. **Assumptions for Case 1: Swedish electricity market is sheltered**

Generation	Per cent of time used on the margin	Variable costs SEK/kWh	Cost increase due to existing legislation SEK/kWh	Cost increase with 0.36 SEK/kg CO_2
Hydro	0	0.01	0	0
Nuclear	15	0.07	0.03	0
CHP (biofuel)	10	0.08	0	0
CHP (coal)	10	0.07	0.01	0.13
CHP (oil)	10	0.11	0.01	0.11
CP (coal)	10	0.12	0.02	0.30
CP oil 1	15	0.18	0.04	0.26
CP oil 2	15	0.19	0.10	0.26
CP oil 3	15	0.19	0.20	0.26
Gas turbine	0	0.55	0	0.34
Average price, öre/kWh		0.14	0.19	0.31*
METR			36%	121%

* With the price increase from 0.19 to 0.31 SEK/kWh the electricity demand is estimated to decline by 7 per cent.

In the case of sheltered electricity and newsprint sectors, the METR on marginal costs in electricity generation would already be as high as 36 per cent under existing legislation. The reason for this is mainly that the power companies in general have not chosen to invest in cleaning devices for the oil-condensing power plants. To be able to use these plants, they would have to rely on expensive oil with low sulphur content, often light oil. Under the assumption that generators should also pay a CO_2 tax at SEK 0.36 per kWh as do other sectors, the METR would increase to 121 per cent.

When the trading possibilities between the Nordic countries are taken into account, it is estimated that coal-fired power plants are on the margin 70 per cent of the time. It is usually Finnish power plants that are determining the price since they pay somewhat higher net tariffs than the Danish power companies. The rest of the time oil-condensing power plants are the marginal suppliers to the system.

In the case with CO_2 taxes applied only in Sweden, it is estimated that Swedish oil-condensing power will be on the margin in the system only 10 per cent of the time, during peak hours. 20 per cent of the time the OCPs in Finland and in Denmark would determine the price level.

For the calculations used in Chapters 6 and 7, it has been noted that the pulp and paper industry in Sweden paid around SEK 0.25 per kWh for electricity in the base year, 1995. This price is higher than the estimated spot-price on the market that year, which was SEK 0.19 as reported in Tables 2.4 and 2.5. A reason for this difference is that the price actually paid (SEK 0.25) includes transportation costs and extra costs that have to be accounted for in a long term contract. The fact that the electricity market was still regulated in Sweden in 1995 also contributes to the difference.

Table 2.5. **Assumptions for Case 2: Common Nordic electricity market**

Generation	Per cent of time used on the margin	Variable costs SEK/kWh	Cost increase due to existing legislation SEK/kWh	Cost increase with 0.36 SEK/kg CO_2 only in Sweden
Hydro	0	0	0	0
Nuclear	0	0.07	0.03	0
CHP (biofuel)	0	0.08	0	0
CHP (coal)	0	0.07	0.01	0.13
CHP (oil)	0	0.11	0.01	0.11
CP coal 1	30	0.12	0.02	0.30
CP coal 2	30	0.13	0.03	
CP coal 3	10	0.14	0.03	
CP oil 1	10	0.18	0.02	0.26
CP oil 2	10	0.19	0.09	0.26
CP oil 3	10	0.20	0.18	0.26
Gasturbine	0	0.55		0.34
Average price, öre/kWh		0.15	0.19	0.22
METR			27%	47%

The estimates of the average spot price of electricity in Sweden during the next five years, with and without CO_2 taxes on Swedish electricity generation, are presented in Tables 2.4 and 2.5. The effect of the CO_2 tax on the average price of electricity generation is SEK 0.12 in the closed market scenario and SEK 0.03 under the more realistic open market assumptions. The price effects of imposing an electricity consumption tax of SEK 0.13 per kWh on industrial users are summarised in Table 2.6.

Table 2.6. **Determination of future electricity prices**

	Price 1995 SEK/kWh	Average price during the next 5 years, with CO_2 tax	Average price during the next 5 years, with electricity tax*
Closed market	0.25	0.37	0.47
Open market	0.25	0.28	0.38

* The electricity tax is 0.13 SEK per kWh, but after an estimated demand effect the price increase is limited to SEK 0.10 in both scenarios. The equality of the demand effect is a pure coincidence, since demand and supply elasticities differ in the two cases.

From Table 2.6 the change in marginal effective tax rates (METRs) on electricity for industrial production can be calculated to show an increase from 25 per cent under current policy rules to 135 per cent after the increased CO_2 tax and the electricity tax if the economy is assumed to be closed. In the open economy case, the estimated increase is from 19 to 81 per cent.

3. THE NEWSPRINT INDUSTRY

3.1. The companies

Sweden has many internationally important pulp and paper companies, such as STORA, SCA, Modo, AssiDomän, Korsnäs and Södra Skogsägarna. Some of these companies are major producers of newsprint. Building upon Sweden's natural resources of forests and hydro power, the pulp and paper industry has been, and still is, very important to the economy. The industry is located in areas scattered over the whole country, but to a lesser extent in the larger cities. Another significant feature is that the industry exports about 80 per cent of its total production, mostly to other members of the European Union.

The research for this study has gained from information and ideas provided by experts within the Swedish paper industry. Using this and published sources of information, the research team built its own picture of the situation today and how it may develop in the future.

3.2. Different methods of newsprint production

There are two major techniques used in newsprint production. One is based on virgin pulp and the other on recycled newsprint. Until now, newsprint production from virgin pulp was much more common in Sweden than production from recycled paper, even though the companies all use locally-generated paper for recycling and also import large quantities. According to statistics from the Swedish Environment Protection Agency (Naturvårdsverket), newsprint from virgin pulp in 1995 amounted to 86 per cent of the total newsprint production in Sweden.

Virgin pulp

Sweden has an international comparative advantage in producing virgin pulp (Thermal Mechanical Pulp – TMP). Such production is very electricity-intensive and demands a lot of raw wood as input, although not as much as the production of chemical pulp. Since about 50 per cent of Sweden is covered by forests, there is a large stock of raw material. Historically Sweden has also had access to electrical power at internationally competitive prices.

Pulp for recycled newsprint

During recent years it has become more and more common to produce newsprint by using recycled pulp as input (De-Inked Pulp – DIP). Today, Sweden uses 1.5 million tonnes of paper material for recycling, of which 40 per cent is imported, mainly from Germany. This process is much less electricity-intensive than the processes that use virgin pulp. The DIP processes in use, however, still require some proportion of virgin pulp.

The availability of newsprint for recycling is limited in Sweden compared with the European continent where the population is much larger and thereby consumes much more newsprint. So, in this area, Sweden does not have a comparative advantage over most other countries. To be able to use large quantities of recycled paper, inputs must be transported from the continent and then finally the end product has to be transported back. Balanced against this comparative disadvantage is Sweden's long tradition as a major pulp and paper producer.

Under these circumstances, one would expect Swedish companies to use their knowledge and tradition to invest in production on the European continent and thereby use recycled paper in situ without the unnecessary transportation. On the other hand, there is already a large paper production capacity in Sweden in terms of existing paper machines and infrastructure facilities (for example harbours), with no or low alternative value.

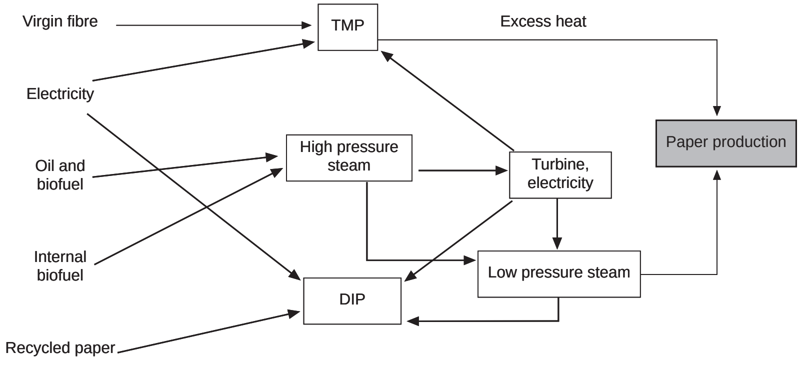
The energy used in newsprint production

The pulp and paper industry is Sweden's biggest single user of electricity. Consumption in 1995 was almost 20 TWh, which was about one-third of the total electricity used by Swedish industry. Another important energy source in the pulp and paper industry is biofuel, primarily bark. Some biofuel is bought from outside sources at market prices, but most is generated internally in the pulping process.

In the TMP process the pulp is made through a mechanical treatment of the wood fibres. The machines that grind the fibres require a lot of electricity. This grinding process also generates a lot of heat that can be used in the process of making newsprint from the pulp. Most of the remaining energy needed to produce steam and heat comes from internally generated fuels. Some minor quantities of oil are also used. The steam that is used typically does not need to be under very high pressure. By allowing high pressure steam to pass a turbine connected to a generator, the pressure and temperature is reduced at the same time as electricity is produced.

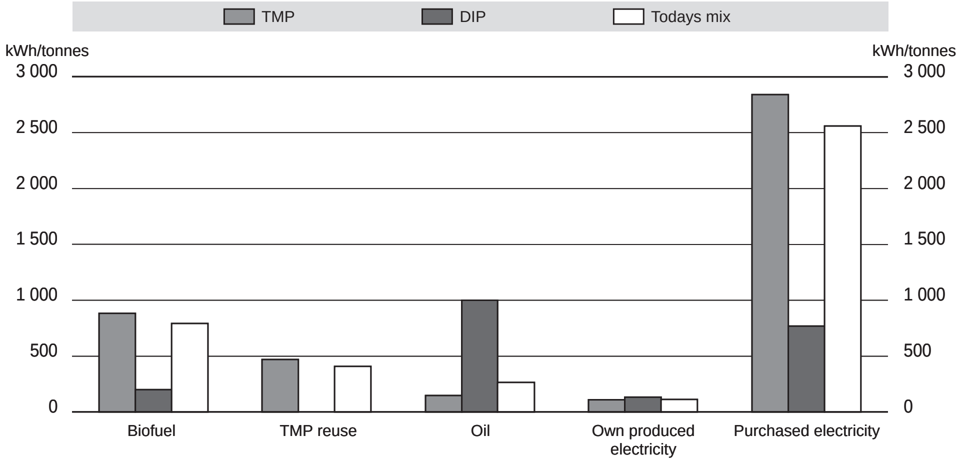
In the DIP process (using recycled paper) there are no wood waste products or excess heat from grinding machines. This means that there is a need to buy more oil and/or biofuel from outside sources. On the other hand, a lot less electricity is needed than for the TMP process. Figure 3.1 provides an overview of the energy use in the two different newsprint production methods.

Figure 3.1. **Energy use in making newsprint in Sweden**



Source: Author.

Figure 3.2. **Specific use of energy in TMP and DIP production and in the current production mix**



Source: Swedish Forest Industries Energy Statistics from 1994, Skogsindustrins utsläpp till vatten och luft samt avfallsmängder 1995, Swedish Environmental Protection Agency.

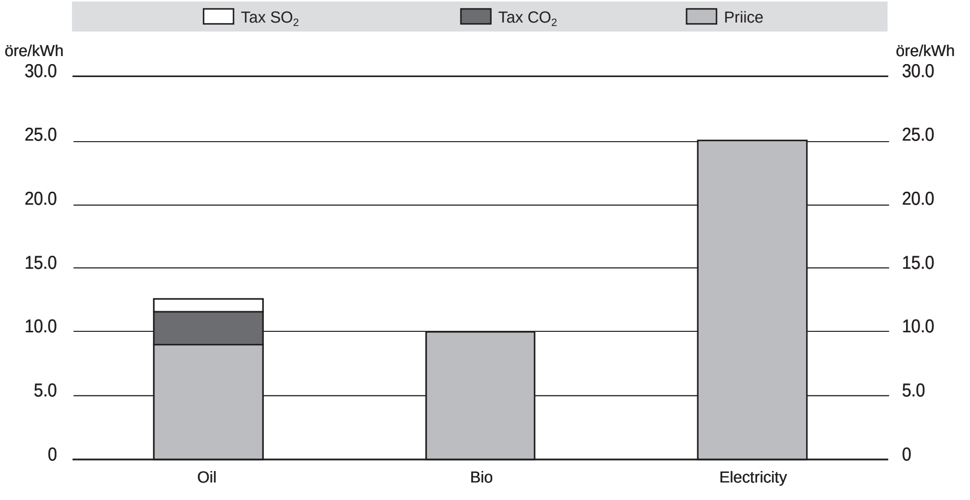
As mentioned above, 86 per cent of the newsprint produced in Sweden is made using the TMP process. Figure 3.2 illustrates the specific energy use (*i.e.*, use per tonne produced) in the two processes separately and in the particular production mix that was the outcome of costs and prices in the mid-1990s.

Energy costs

The energy prices for newsprint producers in 1995 are reported in Figure 3.3. The taxes on energy products were introduced in Section 1.4. There is no carbon tax on biofuels because the biofuels absorb the same amount of CO_2 when they are growing as they release during their combustion.

The different biofuels used in making newsprint differ in price. In general, internal biofuel from the TMP process has no or only a low alternative value. If biofuel is bought on the market, which is often the case for the DIP process, it costs about the same as oil with today's taxes.

Figure 3.3. **Energy prices for newsprint producers, 1995**



Source: Official prices, own estimates.

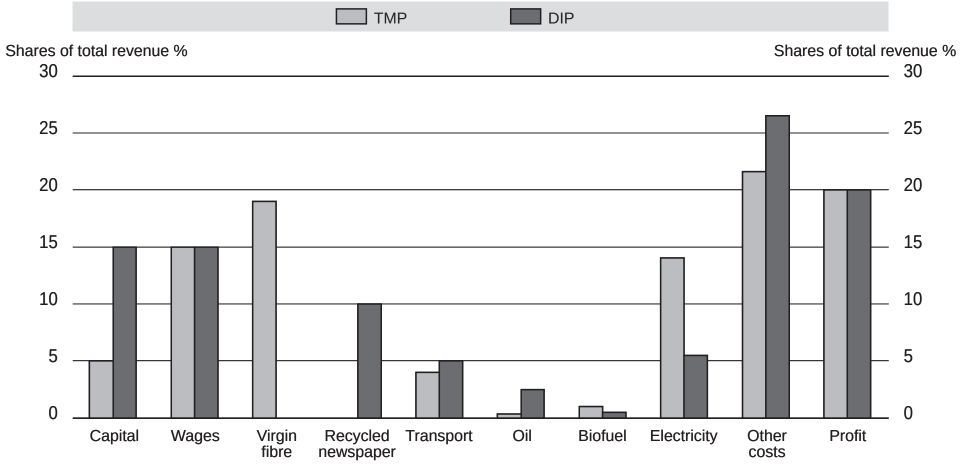
3.3. Total resources used in newsprint production

Figure 3.4 below shows the production costs of newsprint production from virgin and recycled fibre. The bars represent costs as a share of total revenue from the sale of the newsprint made from either the DIP or TMP process. Capital costs have been adjusted to represent a marginal cost share. The reductions are rough approximations based on consultations with company representatives. The marginal cost share for capital in the DIP production is assumed to be a bit higher than in the production of TMP since new investments would be needed to increase output from DIP in Sweden. Swedish TMP production is declining in both cases discussed in the present study, implying only a need for some replacement of depreciated capital.

By expressing the production technology as marginal cost shares, what would happen to profits as a consequence of particular policy measures can easily be calculated. The marginal costs were calculated for a medium term perspective and are presented below.

Profits on the margin in newsprint production are estimated to be 20 per cent of sales for both methods of production. Because capital costs have been reduced to reflect marginal conditions, this profit level will be somewhat higher than the companies' own profitability targets on average over many years.

Figure 3.4. **Marginal cost shares in newsprint production, 1995**



Source: Statistics Sweden and own estimates.

4. EMISSIONS FROM NEWSPRINT AND ELECTRICITY PRODUCTION

There are similarities between the Swedish environmental legislation for the pulp and paper industry and for the electricity sector. As mentioned earlier, there is a sulphur tax on oil, a nitrogen oxide fee and a carbon dioxide tax. The pulp and paper industry also have specific licensing conditions in accordance with the environmental act. These conditions often include limits on total emissions or specific emission limits (mg emissions/MJ used fuel). For some plants, the requirements have not yet been determined, but will be so after a test period during which the possibilities for emission reductions will be examined.

For this study there is a need for estimates of the emission levels in current newsprint production. Table 4.1 presents estimates of specific emissions from the use of biofuel and burning oil in an average newsprint factory in Sweden. The information has been collected from official statistics. As discussed above, this report considers only emissions of SO_2, NO_x and CO_2 to the air.

No information was available on the separate emissions of NO_x from oil and biofuel. This was handled, after interviews with industry, by assuming that there are equal emission rates per kWh of energy used from the two fuels. As mentioned in the preceding chapter, biofuel is assumed to absorb its own emissions of CO_2.

Table 4.1. **Specific emissions for an average newsprint factory in Sweden**

	CO_2	SO_2	NO_x
Burning oil	79 500 mg/MJ oil	80 mg/MJ oil	
Biofuel	0	45 mg/MJ bio	
Total			43 mg/MJ fuel

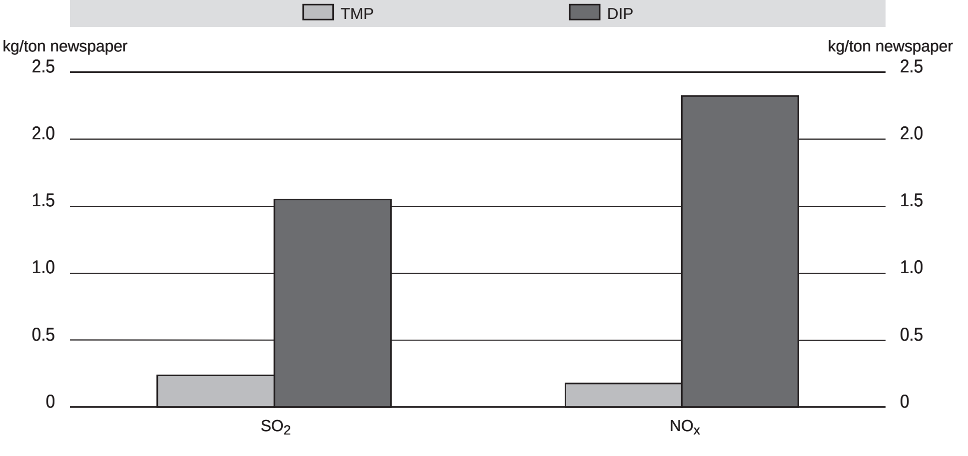
Source: Swedish Environmental Protection Agency 1995, Energy statistics 1994 and own estimates.

The emissions of SO_2 and NO_x to the air from TMP and DIP processes can be seen in Figure 4.1. These numbers are calculated by combining information from Table 4.1 with that in Figure 3.2.

As can be seen, the specific emission rates are much higher from the DIP process compared to the TMP process. This is also the case with CO_2 emissions where the figure is 18 000 kg CO_2/ton paper in the DIP process compared with 5 000 kg/ton paper in the TMP process.

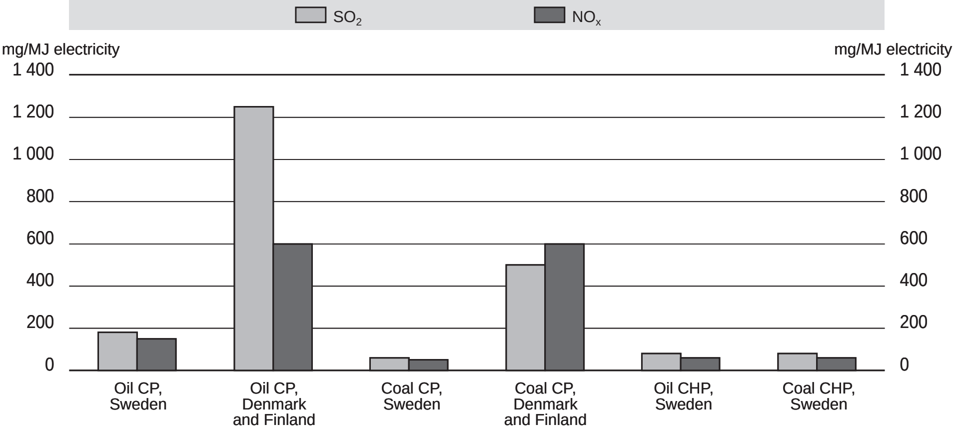
To be able to calculate the total emissions to the air from newsprint production, the marginal emissions from electricity generation are also needed. From Chapter 2, there is information on what type of production process will be operating

Figure 4.1. **Specific emission rates of SO_2 and NO_x in newsprint production**



Source: Swedish Environmental Protection Agency 1995, Energy statistics 1994 and own estimates.

Figure 4.2. **Marginal emissions in electricity generation**



Source: Regulatory constraints on Swedish power stations and own estimates based on contacts with officials at Swedish Environmental Protection Agency in Sweden, Energistyrelsen in Denmark and FinnEnergy in Finland.

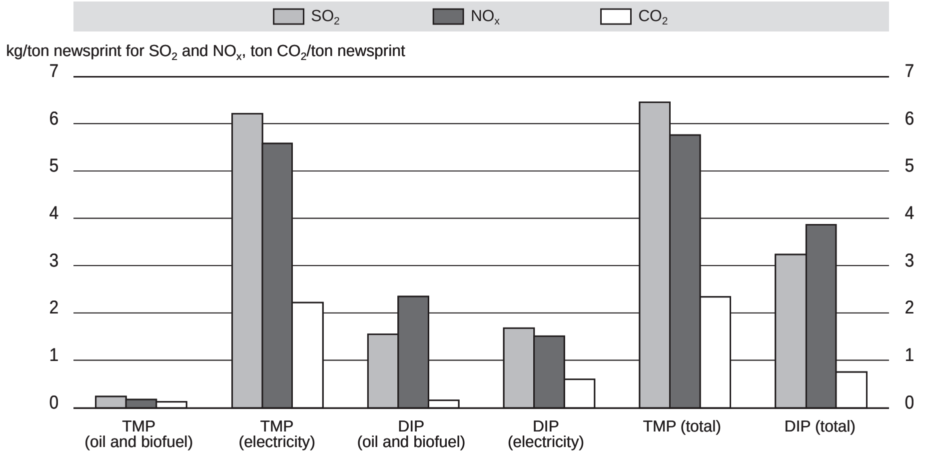
on the margin. In the analysis carried out for this paper, it is assumed that the electricity balance will be much tighter than today – with demand much closer to available supply levels. This is because we look at the effects of government measures over a 5 year perspective, during which time demand for electricity is likely to increase while supply might diminish.

In Figure 4.2 the emissions of SO_2 and NO_x per MJ of electricity for each of the different energy carriers in the electricity sector are reproduced. These figures represent marginal emissions. In Finland and Denmark, the power plants that are used as base load (*i.e.*, those that are running almost all of the time) have high environmental standards, but the older power plants that are often used as the marginal source usually produce a great deal of emissions. In Sweden, the environmental standards are often as high for these marginal production units as for new base load units.

CO_2 emissions are around 200 g per MJ electricity produced in OCP (oil condensed), about 230 g/MJ from CCP (coal condensed), and approximately 100 g/MJ from CHP (combined heat and power).

Figure 4.3 draws together the emissions from the energy and newsprint production stages to indicate the overall marginal emissions in newsprint production.

Figure 4.3. **Overall marginal emissions of SO_2, NO_x and CO_2 from newsprint production**



As illustrated in Figure 4.3, the marginal emissions of SO_2 and NO_x from the electricity sector are much higher than the emissions from combustion within the newsprint factories. In these estimates, Danish and Finnish power stations are assumed to be on the margin almost all the time. The overall marginal emissions of CO_2 from newsprint production show the same pattern as the emissions of SO_2 and NO_x.

In conclusion then, it is clear that when emissions at the input stage of electricity production are added to those in paper production itself, the production of TMP per tonne of newsprint generates significantly higher emissions to the air than the production of DIP. This is true for all three emissions – SO_2, NO_x and CO_2 – considered in the analysis.

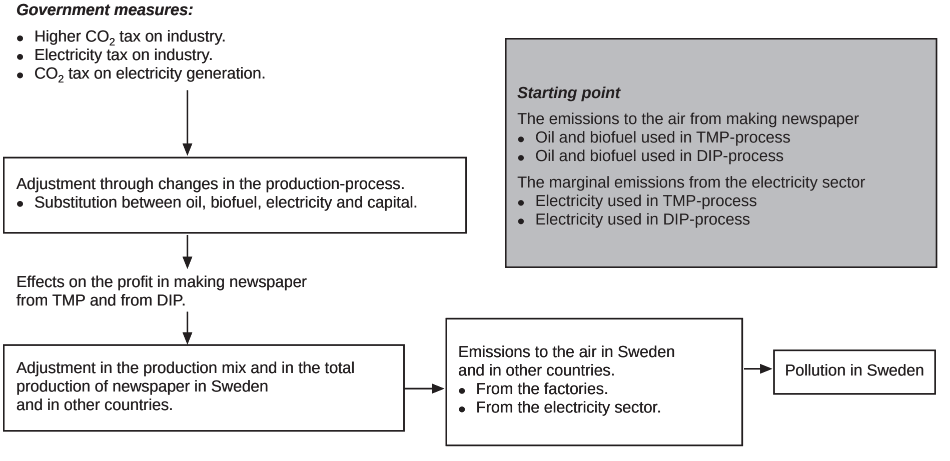
5. AN INTRODUCTION TO THE CALCULATION MODEL

A computerised model was set up in order to co-ordinate all the empirical information needed for this study, and to generate a series of simulations of different scenarios. As was mentioned above, this is neither an econometric model nor a computerised general equilibrium model, but rather a comprehensive calculation tool. It is a model in the sense that it builds on a number of assumptions and incorporates estimates of behavioural responses from earlier research.

This tool, in combination with expert knowledge of the sectors and issues involved, has made it possible to generate some useful insights into the effects of abolishing some of the differentiations in the Swedish tax system. The effects are measured in terms of the environmental and structural economic consequences.

Obviously, the analysis and the quantitative results do not tell the full truth about the issues raised. As always when one goes beyond a pure theoretical approach to try to see how things work in the real world, complications arise, not least because of the shortage and unreliability of empirical data and uncertainty about the magnitude of response mechanisms. Therefore the work presented in this report should be seen as an empirical illustration of how government policy measures affect the environment. In doing so, it also demonstrates the very complexity and difficulties involved in predicting the effects of such government policies. An overview of the calculation model is provided in Figure 5.1.

Figure 5.1. **A schematic view of the calculation model**



The state of emissions in the starting point was described in Chapter 4. Earlier chapters have also provided some basic assumptions about electricity and oil prices in the different scenarios to be analysed. We will return to these when the scenarios are described in more detail.

5.1. Adjustment through changes in the production process

The first adjustment to price changes, as described in the calculation model, is a substitution between oil, biofuel, electricity and capital. These reactions are captured by a set of own-price and cross-price elasticities, corresponding to estimates made by the former National Energy Agency (for example in E*lpriser och svensk industi*, E*nergiverket*, 1989).

The elasticity values are presented in Table 5.1, which shows, for example, that a 1 per cent increase in the price of oil leads to a reduction in the use of oil by 0.7 per cent. The oil price increase also leads to an increase in the use of biofuel by 0.8 per cent, of electricity by 0.01 per cent and a reduced use of capital by 0.7 per cent.

Table 5.1. **Own-price and cross-price elasticities in the process of making newsprint**

	Burning oil	Biofuel	Electricity	Capital
Burning oil	–0.7	0.8	0.01	–0.7
Electricity	0.002	0.001	–0.03	0.008

The same elasticities are used for the TMP and the DIP processes in the calculations. As will be shown below, these adjustments do not have much effect on the production costs or the level of emissions.

5.2. Adjustment in the production mix and in total production

The resulting adjustment in the production mix and in total production levels is much more relevant to the final results. In estimating these reactions, use is made of elasticities in production levels with respect to changes in profit. Changes in profit are measured after completion of the factor substitutions that were generated by the policy changes.

There is a crucial difference in magnitude of the elasticities, depending on the degree of openness of the economy. As mentioned before, a case where the sectors under study are sheltered from international competition has been described in order to put the conditions of the real world into perspective. Elasticities for the two cases are shown in Table 5.2. In the case of competition from the international newsprint market, production can move to other countries if the costs become too high in Sweden. This would, of course, lead to adjustments in Swedish production levels. This is shown as higher elasticities.

Table 5.2. **Elasticities of production with respect to changes in profit**

	International market			Isolated Swedish market		
	TMP	DIP	Newsprint	TMP	DIP	Newsprint
TMP	1.1	–0.3	0.76	0.22	–0.06	0.15
DIP	–0.1	3	3	–0.02	0.60	0.60

The "profit elasticities" show, for example, in the case of international competition, that a reduction in the profit associated with making newsprint using the TMP process by 1 per cent leads to a decrease in TMP production by 1.1 per cent. At the same time, there will be an increase in the production of newsprint from recycled paper (DIP) by 0.3 per cent. The total decrease in Swedish newsprint production would be around 0.8 per cent. The effects in the case where the sectors are sheltered would be much smaller.

The "profit elasticities" were calibrated against the results of other studies. The main source used was the report mentioned above from the former National Energy Agency in Sweden (*Elpriser och svensk industri*, *Energiverket*, 1989). That report calculated the effects on the pulp and paper industry of a cost increase generated by an increase in the electricity price by 20 öre/kWh. It was estimated that this implicit drop in profit levels would lead to a reduction in the production of newsprint by 35 per cent. Other estimates by the agency indicated similar, or even slightly higher, responses to increased electricity prices in the electricity intensive industry in Sweden.

5.3. Emissions to the air in Sweden and in other countries

The effects on emissions to the air of changes in the production of newsprint in Sweden can be calculated by applying the specific emission factors described in Chapter 4. To estimate what happens to emissions in other countries, information is needed on how discontinued newsprint production in Sweden would be replaced by production in other countries. Calculations in this respect were carried out on the basis of two scenarios – assuming low and high emissions in other countries respectively. These alternatives combined assumptions regarding production effects and emission rates.

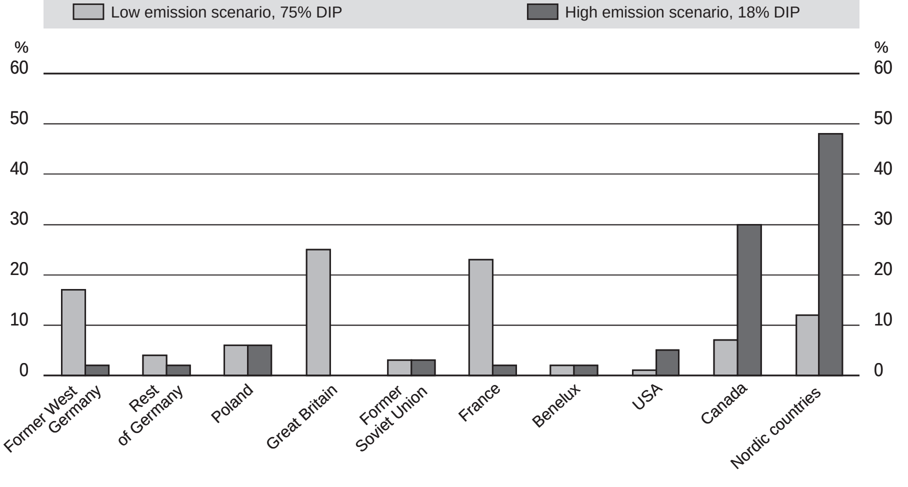
For the low emission scenario, it was assumed that 95 per cent of the decrease in Swedish newsprint production would end up in other countries. The remaining 5 per cent would not be replaced at all, but would represent a decline in world demand for newsprint as a consequence of the slightly higher prices.

It is further assumed that the increased newsprint production would mainly be located in countries that have good access to recycled newsprint, such as France, Germany and the United Kingdom. In this alternative, the calculations imply a rather substantial switch from TMP to DIP, with approximately 75 per cent of the TMP reduction in Sweden being replaced by DIP production in other countries.

In the high emission alternative, a higher proportion of the production decline in Sweden is replaced by TMP production in other countries, with the assumption that only 18 per cent is replaced by DIP. In this alternative, there were assumed to be no effects on the overall world demand for newsprint. The effects on production in other countries are summarised in Figure 5.2.

For each of these countries, an estimate was made of the size of the emissions that would be generated from this additional paper production. This is, of course, impossible to do with precision without a more thorough investigation of the environmental policies and technologies in place in each country – and of their electricity markets. This has not been possible in this study. Some useful information was however extracted from a publication by NUTEK Analys: E*lmarknaderna i* E*uropa* (The Electricity Markets in Europe), 1992. The results presented below should therefore

Figure 5.2. **Increased newsprint production in other countries, as a per cent of reduction in Sweden**



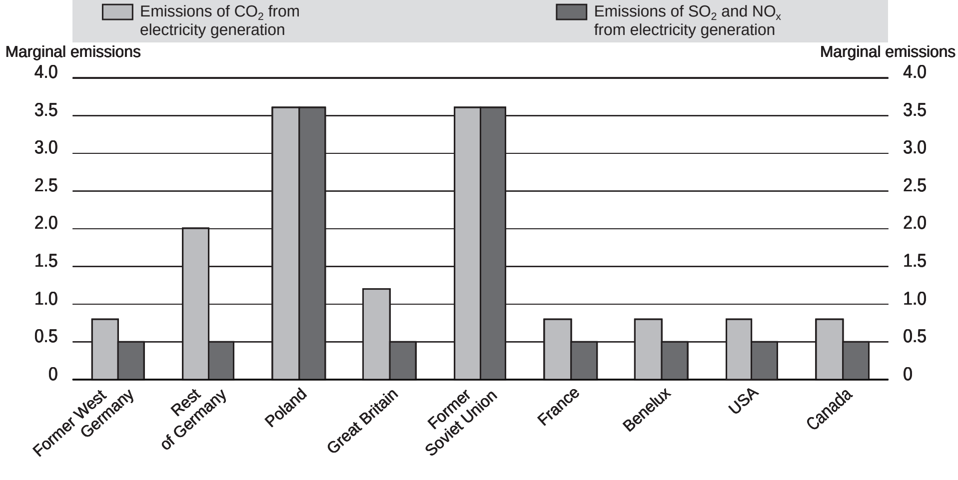
Source: Own estimates.

be regarded as giving only a very rough indication of the expected effects. These measurement difficulties are one of the reasons why the present study applies a sensitivity analysis by modelling results for two alternative sets of assumptions.

It has been assumed that there is, relatively speaking, a low overall energy efficiency in the countries from the former Soviet block and also, for the time being, comparatively low environmental standards. For the other countries of relevance, two different alternatives are considered: high versus low emission rates on the margin.

In the low emission alternative, which is the result of an assumption that there would be a substantial switch from TMP to DIP, marginal emissions to the air from the electricity sector are assumed to be lower in non-Nordic countries than in the Nordic area (Figure 5.3). The rational for this, in the case of countries such as France, Germany and the United Kingdom, is that there is available access in these countries to natural gas which provides cost-effective possibilities for combined heat and power production in DIP plants. For the USA and Canada, the low emissions are the result of an assumption that hydro or nuclear power would be used on the margin in some geographical areas.

Figure 5.3. **Marginal emissions in non-Nordic compared with Nordic countries under the low emission scenario. Nordic countries = 1**

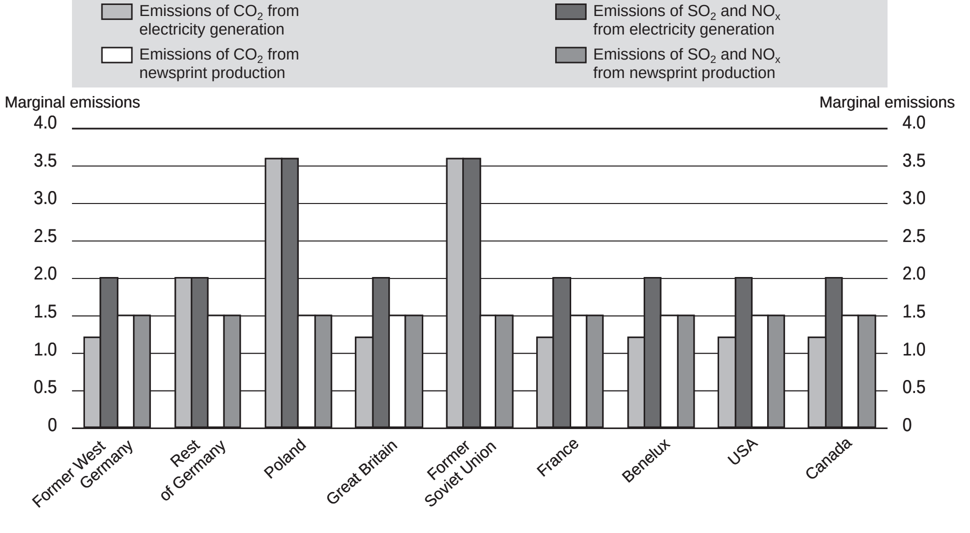


Source: Own estimates.

This scenario builds on 20 per cent lower CO_2 emissions compared with the Nordic electricity system, and 50 per cent lower emissions of NO_x from power production. Due to the use of natural gas in combined heat and power cycles, it is also assumed that SO_2 emissions are 75 per cent lower for an important share of the DIP production that moves to other countries.

In the high emission scenario, it is assumed that marginal emissions from electricity generation are higher in non-Nordic than in Nordic countries (Figure 5.4). CO_2 emissions are taken to be 20 per cent higher and emissions of SO_2 and NO_x 50 per cent higher. The basis of these assumptions is that in these other countries, as in the Nordic area, it is generally the old and rather "dirty" coal- and oil-fired power plants that are used on the margin, even though the bulk of the production capacity might be clean. The national electricity systems in Europe are also linked together as they are in the Nordic area. This implies the possibility that production units in, for example, Poland could be used on the margin in Germany or units in Spain on the margin in France. In this alternative, the emissions from newsprint factories outside Sweden are also taken to be higher than those in Sweden.

Figure 5.4. **Emissions from electricity generation and newsprint manufacturing under the high emission scenario. Nordic countries = 1**

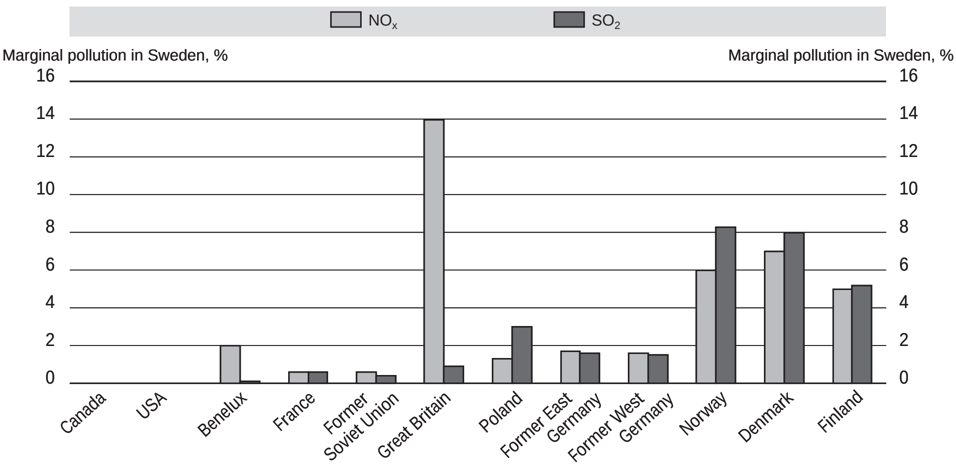


Source: Own estimates.

5.4. Pollution in Sweden

To understand how a policy to impose the standard CO_2 and electricity taxes on electricity generation and newsprint production in Sweden would affect pollution levels within Sweden, it is necessary to estimate the proportion of the emissions in other countries that end up as pollution in Sweden. These marginal pollution rates are shown in Figure 5.5 below.

Figure 5.5. **Pollution that is deposited in Sweden from other countries, as a per cent of total emissions of SO_2 and NO_x in the originating country**



Source: Swedish Environment Protection Agency, Monitor, 1988.

In the following chapters, the effects of government measures will be described in terms of the two cases that have already been referred to: *i*) the relevant sectors are sheltered from international competition; and *ii*) Sweden has an open economy.

6. SHELTERED SECTORS – A THEORETICAL CASE

6.1. Introduction

The analysis of the predicted effects of the higher energy prices that would result from the government measures under study will begin with an examination assuming a closed economy context. This case does not coincide with existing realities, particularly the important facts that Sweden exports 80% of its produced paper and that the Swedish electricity system is integrated with those of other Nordic countries. However, in order to explain the mechanisms involved in an economy's reaction to changes in subsidies, it can be useful to start with a simple case such as this one. Another reason for this approach is that the debate over policy measures is sometimes dominated by arguments relating to a closed economy. It will be clear from this, and the following chapter, that the effects in a closed economy context are likely to be very different from those in a more realistic open market scenario.

It might be useful to repeat at the outset that the policy induced price changes to be analysed are as follows:

1. An increase in the electricity price by SEK 0.22 per kWh for the pulp and paper industry. This is a price increase of about 90 per cent, and is caused by the imposition of a CO_2 tax on Swedish power producers of SEK 0.36 per kilogram CO_2 emitted combined with an electricity tax on the manufacturing industry of SEK 0.13 per kWh. (For further details, see Chapter 2.)
2. An increase in the oil price for the pulp and paper industry by approximately 60 per cent compared to the price in 1995. This is caused by an increase in the CO_2 tax from SEK 0.09 to 0.36 öre per kilogram CO_2 emitted to the air.

6.2. Closed economy effects

In the closed economy scenario, and given the assumptions described in Chapters 4 and 5, it is estimated that the policy measures would increase the cost of producing TMP paper in Sweden by about 14 per cent compared with 1995. Of this, 12 percentage points would be the result of increased electricity prices and 2 percentage points because of higher costs of fossil fuels. DIP paper would cost 6 per cent more to produce, of which higher fossil fuel prices would be responsible for 1.5 percentage points. All this is before any quantity adjustments to the new prices of electricity and oil have occurred.

The next round of calculations are based on two types of adjustments. First, there is a substitution between production factors due to changes in their relative prices. This involves a shift from electricity and oil to biofuels and capital (efficiency measures). Under the assumptions used, this substitution will reduce the cost of TMP and DIP production by only 0.6 percentage points.

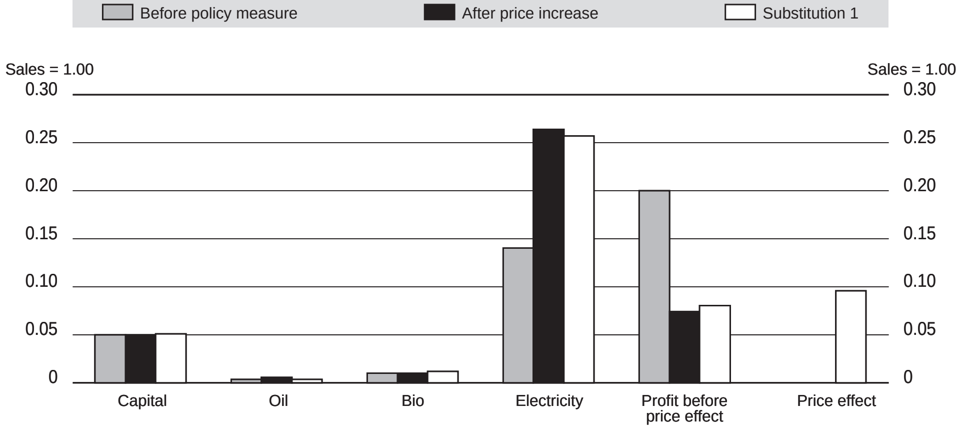
Second, there is a substitution between TMP and DIP production and an adjustment in the total production levels of newsprint. It is assumed that there will only be a small decrease (2 per cent) in the production and consumption of newsprint in Sweden. The decrease lies wholly in TMP produced newsprint, with levels of DIP produced paper unchanged. It is possible to maintain the production levels almost unchanged because of an estimated 10 per cent price increase on newsprint, which corresponds to about 80 per cent of the initial cost increase caused by the higher taxes to the newsprint producers. The reason for this price reaction is that, in a closed economy, the demand for paper is highly inelastic. This makes it possible for the paper industry to shift the bulk of its cost increase forward onto the paper consumers.

6.3. Effects on energy use

Total energy use shows only a modest change in the closed economy scenario. This is because the total production of newsprint is almost unchanged and the shift from TMP to DIP production is very limited.

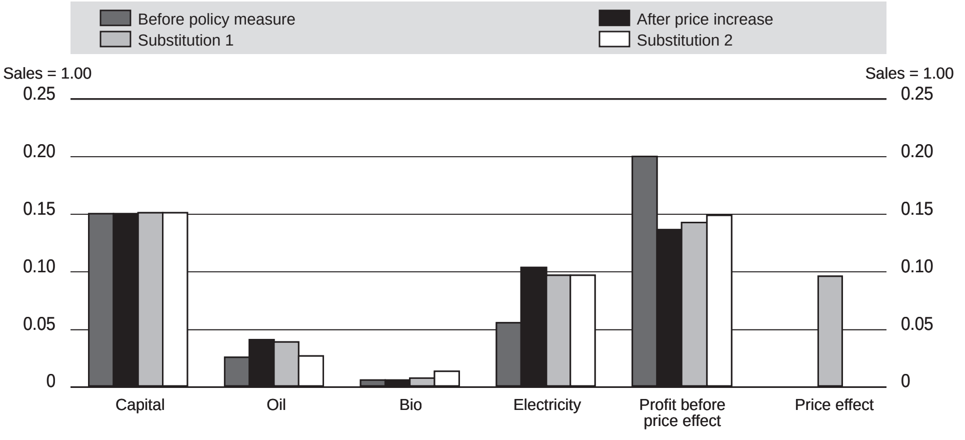
Figures 6.1 and 6.2 provide a summary view of the adjustments. The first bar in the set for each production factor shows the cost shares before the policy changes take place. After the tax increases, prices will increase on electricity and oil which will reduce the profits of the newsprint producers. This situation, before any adjustments occur in the quantities of inputs used, is shown by the second bars. These cost increases will make it profitable to adjust the share of production factors used, thus offsetting to some extent the decline in profits. However, the substitution effect derived from the own and cross-price elasticities shown in Table 5.1 (Substitution 1) was found to affect the use of input factors in only a minor way.

Figure 6.1. **Total energy use in newsprint production before and after adjustment to higher electricity and oil prices, TMP production**



Source: Author.

Figure 6.2. **Total energy use in newsprint production before and after adjustment to higher electricity and oil prices, DIP production**



Source: Author.

A more important effect is the substitution from oil to biofuels that results from the increased CO_2 tax on fossil fuels. This (Substitution 2) is, however, only possible in the production of DIP paper, thus it is only shown in Figure 6.2.

The price increases of newsprint are shown in the Figures as the "price-effect". This effect, together with the resulting profits levels after all the substitutions occur, gives the total profitability after all adjustments. For TMP, the profits would be expected to fall below the original 20 per cent. However, the profits in DIP production would actually increase over 20 per cent. This is because the price increase will be determined by the dominating TMP production on the Swedish market, which will be compensated for its significant cost increases to a high extent. But DIP production will not suffer from the same cost increases. In Figures 6.1 and 6.2 the overall profit effect can be calculated as the sum of the "profit before price-effect", after substitutions and the "price effect".

6.4. Changes in emissions

To translate the changes in energy use to changes in emissions, information is needed on the magnitude of emissions from the Swedish newsprint industry in its use of oil and biofuels and the emissions from the most expensive power plant in use (*i.e.*, the marginal emissions). The assumptions behind these calculations were described in Chapters 4 and 5.

As shown in Table 6.1, the calculations suggest that the reduction in the emissions to the air would be limited in this scenario. The only effect of any significance would be the reduction of CO_2 emissions, due to the substitution from oil to biofuel in the DIP process.

Table 6.1. **Emissions in tonnes from newsprint production and from the electricity sector before and after adjustments are made to the higher electricity and oil prices**

	CO_2			SO_2			NO_x		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
Newsprint production	374 000	273 000	–100 000	920	910	–10	1 030	1 040	10
Electricity production	3 613 000	2 549 000	–64 000	2 050	2 000	–50	1 680	1 640	–40

Taking this one step further by looking at the effects on pollution levels in Sweden (actual falldown of pollutants) rather than on emissions, an even smaller decline is estimated as a result of the policy measures. The total pollution (falldown) of SO_2 and NO_x in Sweden was estimated to decline by only 11 tonnes and 4 tonnes respectively per year.

It must, however, be remembered that these results are generated under the assumption that Sweden is a closed economy. This is, of course, highly unrealistic since Sweden exports about 80 per cent of its total newsprint production. These results would be more relevant if the study was instead examining joint policy measures for a whole region, such as North America or Europe.

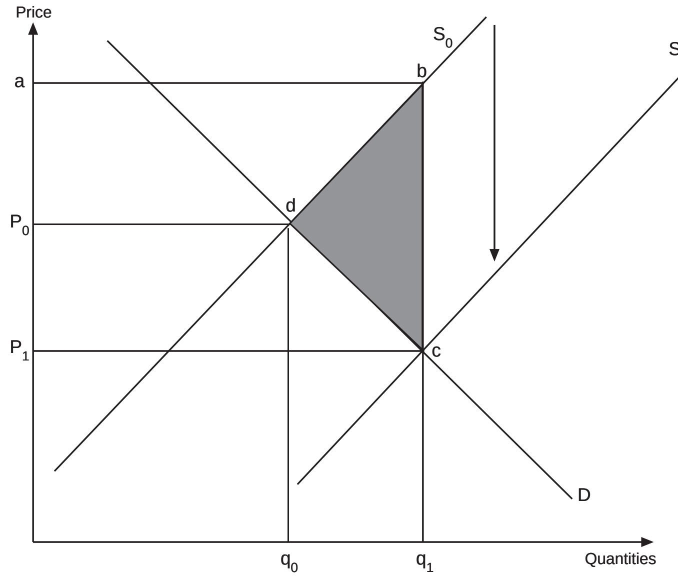
The next section provides a brief, theoretical discussion regarding the cost of subsidies in a closed economy as opposed to an open economy.

6.5. Efficiency gains and losses from subsidy policies

This section starts by addressing the cost side of subsidies which are introduced to improve the framework conditions for particular industrial sectors. It goes on to discuss the possible gains from subsidy removal in terms of improved efficiency of the markets. Finally, it warns that subsidy withdrawal may lead to adjustment costs in the short to medium term.

The efficiency cost to the economy of a specific subsidy can be illustrated by the use of partial equilibrium analysis. Figure 6.3 shows demand and supply (D and S) in a market. It is assumed that the market is unaffected by external effects

Figure 6.3. **Demand and supply before and after a subsidy to production**



Source: Author.

and policy instruments in the initial equilibrium. The introduction of a subsidy to production at the rate of *b-c* per unit of quantity can be shown as a downward shift in the supply curve from S_0 to S_1, as production will be less expensive as a result of the subsidy. The initial equilibrium at (p_0, q_0) will be changed to a new one at (p_1, q_1), with lower sales prices and higher quantities produced as a result.

Tax payers have to pay the financial cost of the subsidy, the size of which is represented by area $abcp_1$. As will be discussed further below, the overall cost to the economy of the subsidy may be higher than the necessary tax revenue, due to the distortionary effects of the tax.

On the benefit side, producers will gain from the subsidy since the producer surplus will increase corresponding to the area p_0abd. Consumers will also gain as the consumer surplus will increase as shown by the area p_0dcp_1. Comparing total benefits and costs to society on this market reveals a net cost as represented by the triangle *bcd*. This is a welfare loss, or excess burden, originating from the fact that the subsidy interferes with the market.

Effects on electricity prices – a recapitulation

Returning to the problem under study, a figure similar to Figure 6.3 could represent the effects on the overall electricity market in Sweden when CO_2 taxes are introduced on electricity production and industrial companies have to pay the same taxes as households on their electricity use, in addition to the CO_2 tax on their use of fossil fuels.

The CO_2 taxes would increase the costs of producing electricity, especially during winter when oil-condensing power is needed in Sweden. This elimination of the preferential tax treatment would imply a shift in the supply curve to the left from S_1 to S_0. The increased tax on the use of electricity in industry would lead to a shift to the left in the demand curve for electricity (not shown). Although the net result on the price of electricity from these shifts is unclear *a priori*, it turns out as an empirical result that the net effect would be a price increase, with a simultaneous fall in the equilibrium quantity.

The price effect on electricity was quantified in Chapter 2. In the case of a closed economy, the price increase was much higher (0.22 SEK/kWh) than in the open economy case (0.13 SEK/kWh). The reason is that, in the latter case, some electricity will be imported from coal and oil-condensing power plants in Denmark and Finland, where there are no CO_2 taxes on electricity production. This would be a consequence of the reduced use of Swedish oil-condensing power stations, since they would have become more expensive with the higher CO_2 taxes. According to the analysis in Chapter 2, the degree of utilisation of these Swedish plants would be reduced from about 30 per cent of potential operating time to around 10 per cent. The less Swedish oil-condensing power stations are used during the year, the lower the average price-increase will be of the electricity supply. Since the industrial sector uses roughly the same amount of electricity throughout the year, it is the average price-increase which is relevant for the behavioural reaction.

In terms of a graphical illustration, the open economy case can be distinguished from the closed economy scenario by a smaller shift in the supply curve. Another difference would be the slope of the demand curve: if Swedish producers are not sheltered from international competition, the price elasticity of demand for industrial products will be much higher than in the closed economy scenario, and therefore the elasticity of derived demand for electricity will also be higher. The reason is that competitors in other countries would increase their market shares on the world market if the costs in Sweden rose (*i.e.*, production would shift overseas). Alternatively, Swedish companies may set up subsidiaries to produce from abroad.

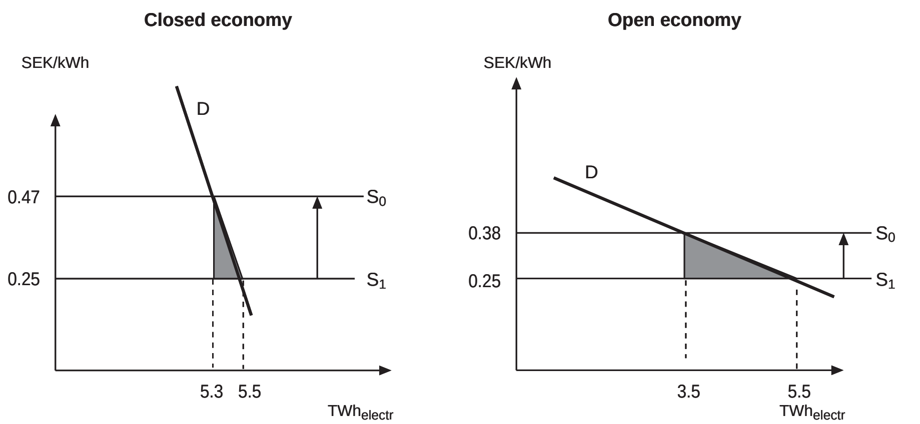
Efficiency gains quantified

Based on an elementary partial equilibrium analysis, it is possible to make some rough estimates of the welfare gains to the economy if the Swedish electricity and newsprint producing sectors were to lose their preferential treatment regarding electricity and CO_2 taxes. A similar effect to the one discussed above regarding the electricity market would arise when producers of newsprint were obliged to pay the same CO_2 tax as households and other groups. The cost of using fossil fuels would increase. In relative terms, this effect would be less important for the industry than the increase to their electricity costs because the cost share for electricity is much higher than for fossil fuels.

This analysis assumes that the target levels of the tax rates would be non-distortionary from an environmental point of view, or, in other words, that at these rates the external costs associated with the use of energy would be perfectly internalised. As will be explained further in the concluding chapter, it seems likely however that these tax rates are far too high from this perspective. The implication is that the analysis gives an overestimate of the potential welfare gains from such a policy.

The following analysis of partial welfare effects is restricted to the policy effects on the Swedish newsprint industry, where companies are assumed to be price-takers on the electricity market. The increase in electricity prices that would result from the policy changes under examination are already factored in through an adjustment in demand and supply on the *overall* market for electricity in Sweden and the Nordic area respectively. Therefore, Figure 6.4, which illustrates the sub-market of electricity to the newsprint industry, shows the supply curve for electricity as a horizontal line with a downward sloping demand curve.

Figure 6.4. **Efficiency gains due to the withdrawal of preferential tax treatment**



Note: S_1 is the supply curve while the subsidy is in place, S_0 after it is removed.
Source: Author.

Initially, the electricity demand from the newsprint industry is 5.5 TWh and the electricity price is 0.25 SEK/kWh. Increased taxes on CO_2 emissions in the electricity producing sector and the tax on the industrial use of electricity would increase electricity prices for the newsprint industry by SEK 0.13 per kWh and SEK 0.22 per kWh for the open and closed economy cases respectively.

Figure 6.4 is based on the results from the model calculations. As was discussed above, in the closed economy case the total newsprint production level is rather insensitive to changes in the price of newsprint that would result from increased electricity costs. Since there would be little reduction in electricity use or electricity carrier substitution in this case, electricity demand would be rather stable. In the open economy case, however, as will be discussed further in the next chapter, the effects on newsprint production levels would be quite significant. This, in combination with a substitution from TMP to DIP, will imply a considerable effect on the newsprint industry's demand for electricity in the open economy scenario.

The assumption of horizontal supply curves is fairly reasonable for the closed economy case, since the demand effect is only 0.2 TWh. However, it is more doubtful whether this assumption is appropriate for the open economy case, where the effect on demand was as significant as 2 TWh. On the other hand, in this case we are dealing with a Nordic electricity market which is more than twice as big as an isolated Swedish market.

Table 6.2 presents the calculated efficiency gains from subsidy withdrawal for the newsprint industry's use of electricity. These gains correspond to the triangles marked in Figure 6.4. In a similar way, the efficiency gains with respect to the newsprint industry are calculated for the abolishment of the preferential treatment of the CO_2 tax for industry.

The table confirms that the efficiency gains are higher in the more realistic scenario of an open economy than if there is a closed economy. The total efficiency gains in the open economy case associated with removing preferential CO_2 and electricity tax treatment of industry would be SEK 198 million per year, which corresponds to 14 per cent of the total cost of electricity to the newsprint industry. In the closed economy case, the gains would be limited to SEK 59 million per year. As a consequence of a decline in the demand for newsprint following price rise, the closed economy gain may be somewhat further limited by reduced consumer surplus on the market for newsprint.

Given that the policy measures would also affect other industrial sectors in the economy, the overall gains would of course be expected to be even larger. These effects would be even further enhanced by the efficiency gains that could be realised by reducing other taxes, a policy that would be made possible by the abolishment of the preferential tax treatment.

Table 6.2. **Numerical estimates of efficiency gains that would result from the withdrawal of subsidies to the electricity producing industry and the newsprint industry in Sweden**

	P_1 SEK/kWh	P_0 SEK/kWh	Q_1 TWh/year	Q_0 TWh/year
	Effects of increased electricity price			
Closed economy	0.25	0.47	5.5	5.3
Open economy	0.25	0.38	5.5	3.5
	Direct welfare gains, billions SEK per year			
Closed economy	(0.47 – 0.25) × (5.5 – 5.3) / 2			**0.022**
Open economy	(0.38 – 0.25) × (5.5 – 3.5) / 2			**0.13**
	Effects of increased price on fossil fuels			
Closed economy	0.135	0.203	4.2	3.1
Open economy	0.135	0.203	4.2	2.2
	Direct welfare gains, billions SEK per year			
Closed economy	(0.203 – 0.135) × (4.2 – 3.1) / 2			**0.037**
Open economy	(0.203 – 0.135) × (4.2 – 2.2) / 2			**0.068**

Note: (P_1, Q_1) is the price and quantity of Swedish newspaper with the subsidy; (P_0, Q_0) is the price and quantity after the subsidy is removed.

It should be pointed out that these calculations of efficiency effects relied on a number of simplifying assumptions, such as that there are linear demand and supply functions, and they are abstracted from interactions with other markets and from the possible effects of other taxes and subsidies (*i.e.*, second order problems). The calculations also do not consider the income effects that the price increases might result in.

Structural costs

Most importantly, however, the calculations do not cover the potentially significant adjustment costs, especially in the short to medium term, that would follow from an abolishment of the preferential tax treatment of the electricity and newsprint sectors.

The decision to withdraw a subsidy can lead to idle capital equipment and unemployment. Other sectors in the economy may, at least in the short run, not be capable of employing the workers that are let off by the previously supported industry. To find new employment, the employees may need to move to other areas, which might increase problems of regional imbalances and depressed areas.

The structural problems may be more serious when a subsidy is withdrawn in an open economy than if it was in a closed economy, simply because the production effect would be much bigger if the industry is under competition from other countries where business conditions are more favourable. These issues will be discussed further in the next chapter.

7. SWEDEN AS AN OPEN ECONOMY

This chapter illustrates the effects of reduced government support in a more realistic case, reflecting the fact that Sweden exports about 80 per cent of the total newsprint produced. The existence of the Nordic electricity market, which enables trade between these countries, is also recognised. As a result, one effect of the higher production costs to Swedish power plants that would result from changes in the tax and subsidy conditions would be an increase in the amount of electricity imported from Denmark and Finland. This marginal supply would be almost entirely generated by coal- and oil-fired power stations.

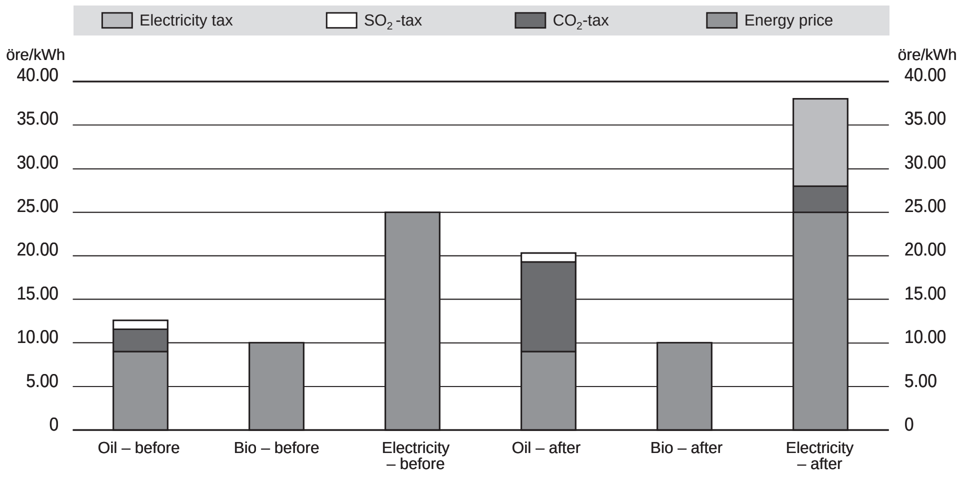
As in Chapter 6, a scenario is analysed where an electricity tax at the level of SEK 0.13 per kWh is imposed on the sectors under study which are currently exempted from this tax. A CO_2 tax on electricity production of SEK 0.36 per kg CO_2 is also assumed to be imposed in Sweden. This will make a big difference compared to the neighbouring countries where it is assumed that such taxes are not in place. Finally, it is assumed that the CO_2 tax on the pulp and paper industry is increased to SEK 0.36 per kg CO_2, an increase of SEK 0.27 per kg compared with the situation in 1995.

As summarised in Figure 7.1 this scenario clearly implies dramatic price increases on Swedish industrial markets. The electricity price would rise by about 50 per cent, with far-reaching consequences for TMP-based production in particular. Oil prices would go up by around 60 per cent, primarily affecting DIP-based production. Oil is, however, not as important for DIP production as electricity is for TMP.

7.1. Forward cost shifting not possible

In this scenario, the paper industry is much more sensitive to cost increases than in the closed economy case. A difference amounting to a factor of 5 has been used in the calculations.[6] This is because the Swedish paper companies tend to be price-takers on the word market. If it is not possible to achieve high enough profit levels in Sweden, production will move elsewhere. In the low emission alternative, it is assumed that 95 per cent of the reduced production in Sweden will be covered from abroad. The remaining five per cent will end up as reduced demand on the world market as a reaction to slightly higher world market prices for newsprint.

Figure 7.1. **Prices and taxes before and after policy measures**



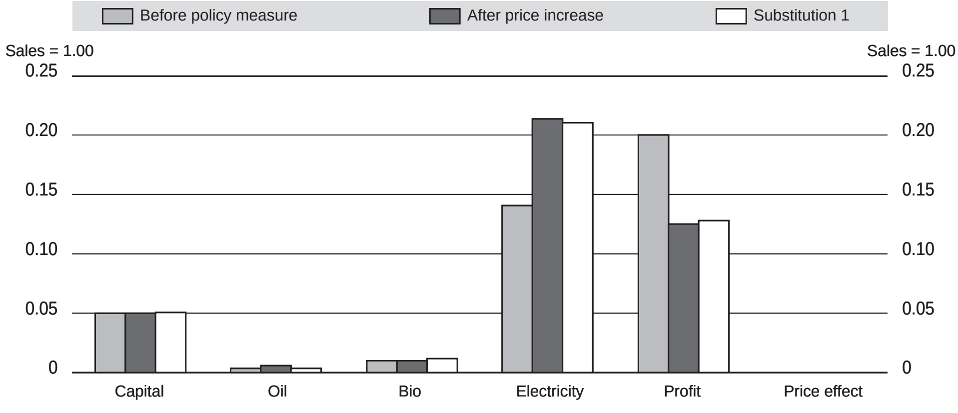
Source: Author.

7.2. Direct price effect and substitution

The increased electricity price will lead to a substantial increase in the costs of the TMP-based process. In reaction to this, companies will try to limit the cost increase as much as possible by substitution from electricity to oil, biofuel and capital. This substitution can, however, only reduce the costs by a modest degree. Figure 7.2 illustrates the cost shares before and after policy changes assuming the same factors of production shares (the first two bars in each set), and the cost share after the reallocation of the factors of production (the third bar, "substitution 1"). The effects on profits are also shown. All changes are relative to the value of sales. The electricity price increase is the main reason behind the fall in profit from 20 to 13 per cent, a drop of 35 per cent.

DIP-based production would also face a cost increase, but not as large as that in TMP-based production. In the DIP process it is easier to shift from oil, which is 60 per cent more expensive in this scenario, to biofuel which is not affected by the CO_2 tax (Substitution 2). Newsprint producer profits would fall after these substitutions from 20 per cent to about 17 per cent in DIP-based production, *i.e.* by 15 per cent, a smaller decline than for TMP-based production.

Figure 7.2. **Level of cost shares and profits in relation to sales in TMP production before and after factor substitutions due to policy changes**



Note: This corresponds to the open economy case of TMP-based production when the electricity price increases by SEK 0.13 öre per kWh and the CO_2 tax by SEK 0.27 öre per kilo.
Source: Author.

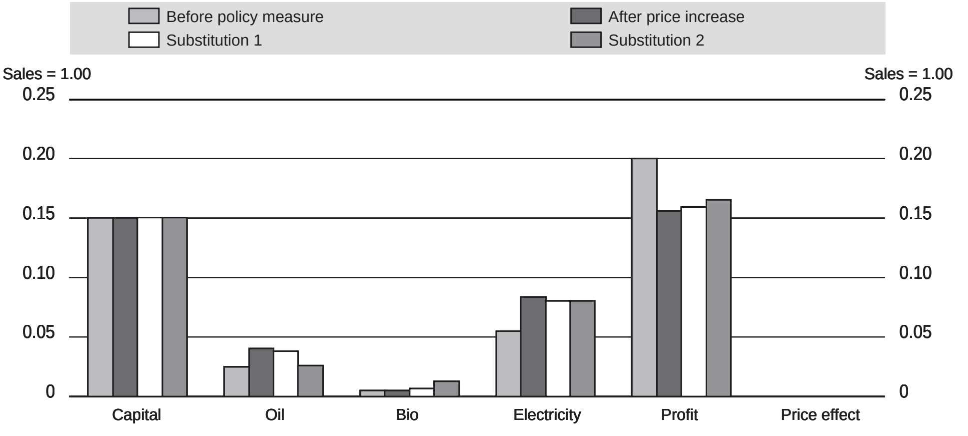
7.3. Sensitive production levels

Once the cost saving substitutions have been made, the question remains as to whether the resulting profitability levels are sufficient for continued production in Sweden. Figure 7.2 showed that the profit rate for making newsprint from TMP would be reduced by 35 per cent, despite substitution possibilities. For DIP, the profit rate would similarly go down by 15 per cent as shown in Figure 7.3. The expected production levels for TMP and DIP were adjusted by applying the profit elasticities given in Table 5.2, resulting in a big decline in total newsprint production combined with a slight shift from TMP to DIP. This shift enables part of the profit decline to be recaptured within the industry as a whole.

The final effects on production and profit levels in TMP and DIP processes were estimated and are presented in Figure 7.4. The total newsprint production in 1995 is scaled to 1.0, of which TMP production accounted for 0.86 and DIP production for 0.14. The profit levels were assumed to be 20 per cent before policy measures.

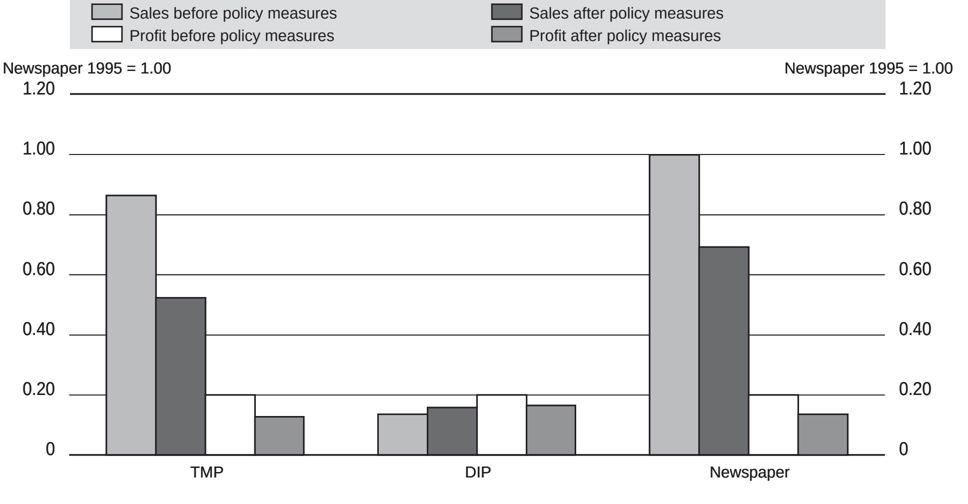
TMP production would be expected to fall by around 40 per cent. If it had not been possible to substitute some of the TMP production with the production of other TMP-based products, the fall would have been even larger. DIP-based

Figure 7.3. **Level of costs and profits in relation to sales in DIP production before and after factor substitutions**



Note: This corresponds to the open economy case of DIP-based production when the electricity price increases by SEK 0.13 per kWh and the CO_2 tax by SEK 0.27 per kilo.
Source: Author.

Figure 7.4. **Sales and profits before and after policy measures**



Source: Author.

newsprint is also negatively affected by the cost increases. On the other hand, DIP-based production can to some extent replace TMP using the existing paper machines and infrastructure such as harbours. It is therefore reasonable to expect, as the calculations indicate, that there would be a slight increase in DIP production when the profits for TMP production fall.

In this scenario, total production of newsprint in Sweden would decrease by 30 per cent. Most of this production will move to other EU countries. One advantage many of these countries have is lower transport costs for recycled newsprint due to their higher populations compared with Sweden. Perhaps even more important is their access to natural gas, which enables them to use the more economic combi-cycle. Under these conditions, they can economically produce heat for the DIP process and electricity at the same time.

Sweden has no access to natural gas, except in the south-west regions. This implies that a major part of the lost TMP production may be replaced by newsprint production based on DIP in other EU countries. As indicated above, it is estimated that DIP-based paper production in Sweden would also increase somewhat.

7.4. Energy use and power supply

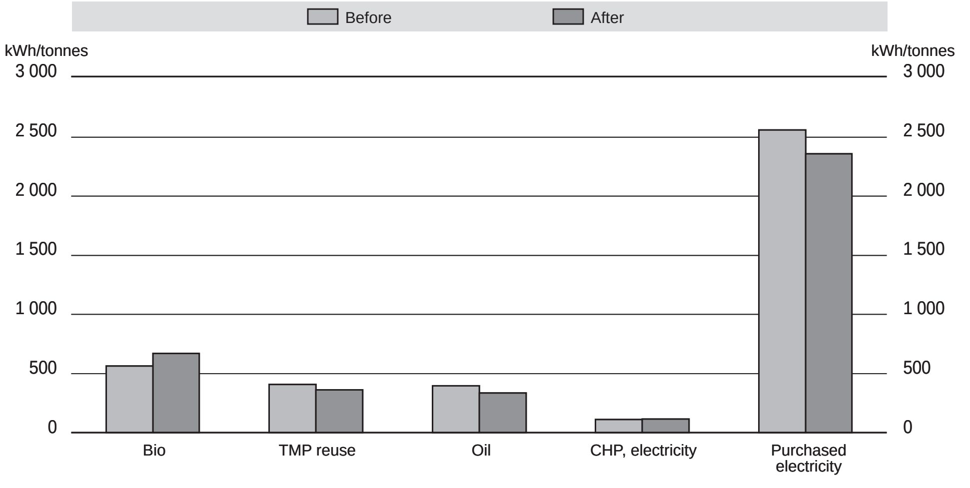
The substitution of DIP-based production for TMP in Sweden as a result of these policy measures would reduce the specific demand for electricity for newsprint production. Together with production changes and small substitution effects, it is estimated that the electricity use in Sweden for newspaper production would fall from 5.5 TWh to 3.5 TWh as a result. The re-use of energy associated with the TMP process would, of course, also decline with the decreased TMP production. On the other hand, the specific demand for biofuel in the new production mix would increase. This is illustrated in Figure 7.5.

7.5. Impact on emissions

In this scenario, some paper production would move from Sweden to other countries, and so too would the emissions that result from this production. Table 7.1 reports the reduced emissions of CO_2, SO_2 and NO_x emissions from Swedish producers of pulp and paper that would be expected.

There would also be a reduction in emissions from the electricity sector. The demand for electricity would decrease partly because of the decline in paper production and partly because of an increased share of DIP in overall production. Even though electricity in Sweden is produced with very low emissions to the air, it is assumed that older Danish and Finnish coal- and oil-fired power stations are actually operating on the margin most of the time. By experience, the Swedish OCP tends to be on the margin 10 per cent of the time, the Danish and Finnish OCP 20 per cent, and their coal-condensing power 70 per cent of the time. Under the

Figure 7.5. **Specific energy use for the mix of TMP and DIP in Sweden before and after policy changes**



Source: Author.

Table 7.1. **Changes in emissions from the Swedish pulp and paper factories**

Tonnes for SO_2 and NO_x, thousands of tonnes for CO_2

	CO_2	SO_2	NO_x
Burning oil	–178	–180	
Biofuel	0	80	
Total	–178	–100	–10

marginal approach taken in this paper, this means that reduced electricity consumption in Swedish factories would reduce the use of these older power plants. This is the main reason why the positive environmental effects are so large, as shown in Table 7.2, in terms of lower emissions resulting from the reduction in Swedish paper production.

7.6. Impact on the world environment

The majority of the reduction in paper production in Sweden would be matched by production increases in other European countries. This would, of course, lead to increased emissions in these countries. As described in Chapter 5,

Table 7.2. **Changes in emissions from the Nordic electricity sector caused by reduced demand from the Swedish pulp and paper factories**

Tonnes for SO_2 and NO_x, thousands of tonnes for CO_2

	CO_2	SO_2	NO_x
OCP, Sweden	–147	–130	–110
OCP, Denmark, Finland	–294	–1 850	–890
CCP, Sweden	0	0	0
CCP, Denmark and Finland	–1 189	–2 590	–3 100
Oil CHP, Sweden	0	0	0
Backpressure, Sweden	0	0	0
Nuclear, Sweden	0	0	0
Total	**–1 630**	**–4 570**	**–4 100**

two alternatives are discussed – one with low and one with high pollution emissions in these other countries. These two alternatives are summarised in Table 7.3.

As can be seen from Figure 7.6 below, it is expected that the policy measures would lead to a total global reduction in the emissions from the newsprint industry in the low emission alternative. The most important determining factors for these results are:

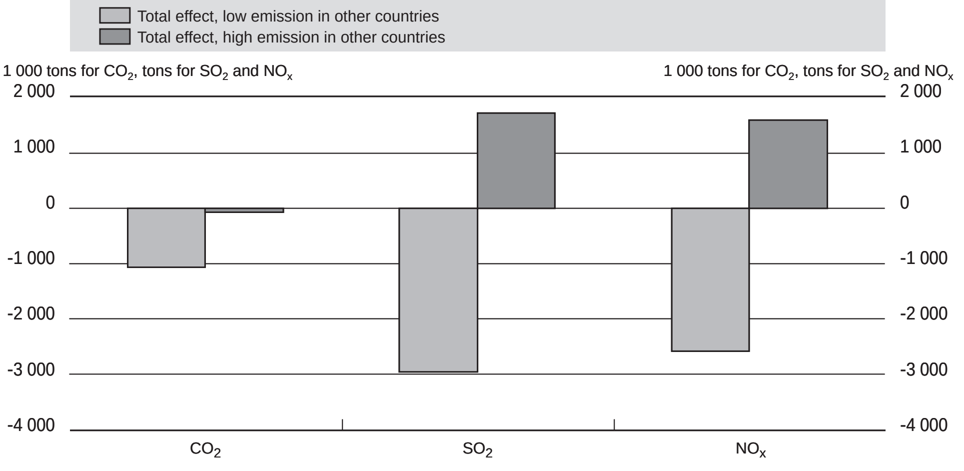
- the increased use of recycled newsprint;
- the assumed lower marginal emissions from the electricity system, largely due to the use of gas combi-cycles; and
- the lower total production of newsprint in this alternative.

Table 7.3. **Marginal emissions from newsprint production in other countries**

	Low emission scenario	High emission scenario
Decline in the world demand for newsprint	5 % of the reduction in Sweden	None
Switch from TMP in Sweden to DIP in other countries	75 % of the reduction in Sweden becomes DIP	18 % becomes DIP
Emissions from electricity generation, OECD area, except Nordic countries. Nordic countries = 1	CO_2 = 0.8 SO_2 = 0.25* NO_x = 0.5	CO_2 = 1.2 SO_2 = 2.0 NO_x = 2.0
Emissions from paper production, OECD countries. Sweden = 1	CO_2 = 1 SO_2 = 0.25* NO_x = 1	CO_2 = 1.5 SO_2 = 1.5 NO_x = 1.5

* Only from Great Britain, France and western part of Germany. 0.5 from the others.

Figure 7.6. **Total changes in emissions of CO_2, SO_2 and NO_x in Nordic countries and other affected countries as a result of environmental policy in Sweden**



Source: Author.

In the high emission alternative, the global emissions of SO_2 and NO_x will increase while those of CO_2 will remain roughly unchanged. The reason why the CO_2 emissions will remain constant is that even in this alternative there is a switch from TMP-based processes to DIP when the production moves from Sweden. How these overall changes are distributed between Sweden and other countries is shown in Table 7.4.

Table 7.4. **Overall changes in emissions in Sweden and elsewhere**

Tonnes for SO_2 and NO_x, thousands of tonnes for CO_2

	CO_2	SO_2	NO_x
		High emission scenario	
Sweden	–1 810	–4 670	–4 110
Other countries	1 640	5 870	5 240
Total	**–170**	**1 200**	**1 130**
		Low emission scenario	
Sweden	–1 810	–4 670	–4 110
Other countries	600	1 020	1 080
Total	**–1 200**	**–3 640**	**–3 030**

Under the assumptions used, the positive effects on emissions in Sweden are large enough in the low emission scenario that they outweigh the increased emissions in other countries. In the high emission alternative, the global emissions would instead increase, because the decrease in Sweden would be smaller than the increase in other countries.

Building on the assumptions introduced in Chapter 5, Table 7.5 completes the analysis of these scenarios by presenting the estimated effects on pollution levels in Sweden. The total effects on pollution would be favourable in both alternatives, even though the effects are rather small when compared with annual emissions of 94 000 tonnes of SO_2 and 362 000 tonnes of NO_x.

Table 7.5. **Effects on pollution levels in Sweden**

	SO_2	NO_x
Pollution in Sweden, low emission scenario	–320 tons	–420 tons
Pollution in Sweden, high emission scenario	–420 tons	–470 tons

7.7. Trade-off between economy and environment

With Sweden realistically described as an open economy, the Swedish newsprint industry would lose world market shares from the tax changes under examination. The loss of gross exports for Sweden would be approximately 7 billion SEK at current prices. The imports needed in this production is low, less than 1 billion SEK. Therefore, the lost net export for Sweden would be at least 6 billion SEK, which corresponds to about 0.3 per cent of Sweden's GNP.

Of course, such a dramatic increase in the electricity price would also affect other electricity-intensive sectors in the Swedish industry. The production would decrease overall in these industries, which could create problems with idle capital resources, unemployment and detrimental effects on the balance of trade.

Because of structural and institutional constraints, it would probably be difficult for the Swedish economy to make the necessary adjustments to minimise the costs which would result from this policy. Employees losing their jobs in the paper industry or its sub-contractors (and in the regional service sector as a result) could face difficulties in finding new employment. Sufficient expansion in other industrial and service companies that could make up for the production loss and, particularly, the loss in net export could be difficult to achieve in the short to medium term. Compensating for the effects on net exports could also be difficult in the longer run, perhaps resulting in a weaker Swedish krona.

If it is realistically assumed that around 1/3 of the initial losses (in terms of reduced paper production or loss of net export) are not replaced by new activities, the cost to Sweden would be about SEK 2 000 million per year. This cost should be compared with the expected environmental gains of the policy. Under the low emission assumptions, the CO_2 emissions were reduced by 1 million tonnes, and the global SO_2 and NO_x emissions by 3 000 and 2 500 tonnes respectively. If half of the financial costs are allocated to the CO_2 reductions, the reduction costs will be equivalent to 1 SEK per kg CO_2. The reduction costs of SO_2 and of NO_x will then be more than 150 SEK per reduced kg SO_2 and 200 SEK per reduced kg NO_x.

These costs associated with achieving emission reductions are very high. This is clear from a comparison with one of the newsprint mills in Sweden, which is able to clean 95 per cent of its SO_2 emissions at a cost of SEK 20 per kg. The same cost level for cleaning SO_2 emissions in Sweden was estimated by a Swedish commission on international co-operation on the environment (Gemensamt genomförande, SOU 1994:140). In the same report, a number of studies were mentioned that indicate a variety of CO_2 reduction measures at costs well below 1 SEK per reduced kg CO_2. Currently, the CO_2 tax in most other countries is low or non-existent.

This illustration using the results from the low emission scenario implies that it would probably be far better for Sweden to make other adjustments domestically to achieve emissions reductions at considerably lower cost than to use the tax solution that is examined here. Alternatively, and even more efficiently, Sweden could provide monetary support to help reduce emissions in other countries that until now have not been in a position to implement some of the more cheaply available cleaning techniques. The observations in this section also suggest the advantages of a policy where Sweden promoted concerted actions in the international field in order to implement environment friendly policies. This would prevent some of the potential losses identified in this chapter.

7.8. An unexpected result

As is clear from this case study, estimating the global effects of tax and subsidy policies on emissions and pollution levels requires access to a wide range of information. Since it was not possible in the present context to explore this with all the detail that would have been desirable, the approach taken was to present two scenarios to reflect the remaining uncertainties. It could be expected, however, that the real world would lie somewhere between the two scenarios.

The results of the calculations indicate that it is quite possible that the total, global emissions from newsprint manufacturing would decline as a result of removing the preferential CO_2 and electricity tax rates to industry in Sweden. This is contrary to what was anticipated *a priori*. The expectations were that, because of the strict environmental legislation in Sweden, the emissions would increase if paper production and electricity generation moved to other countries. The only question was the size of this negative effect on the global environment.

There are different reasons for this somewhat surprising result:

– First, it is an implication of the strict marginal approach applied in this analysis that credit is not given for the fact that Sweden uses very clean hydro- and nuclear power for most of the (non-marginal) electricity produced. These sources, which together stand for about 90 per cent of the Swedish use of electricity, do not lead to any emissions at all of CO_2, SO_2 and NO_x.

– Second, coal-condensing power from Denmark and Finland, generated with fairly high emissions, is most often the marginal source on the Nordic electricity market.

– Third, the use of recycled newsprint increases, perhaps considerably, if production is re-allocated to other countries.

It is thus a result of this analysis that emissions associated with Swedish newsprint production are quite high on the margin, even though Sweden itself has been extremely effective in reducing emissions in the energy sector and the pulp and paper sector in general. Sweden has a very low share of fossil power and the environmental restrictions on this small part are high compared with many other countries. In fact, Sweden has very high standards on the OCPs, despite the fact that they are used only for limited periods in an average year.

8. CONCLUDING REMARKS

A number of significant conclusions can be drawn from this case study on the effects of eliminating the tax differentiations that exist for the electricity and CO_2 taxes in Sweden. The existing differentiation of rates works to the benefit of the two sectors covered in the study: electricity generation and newsprint production. Thus, at first sight, these sectors might be considered to be receiving support from the government.

However, it is by no means clear that the tax incentives given to the sectors should be regarded as subsidies when they are compared with the tax and subsidy conditions for competitors on international markets. It turns out, therefore, that the interpretation of what is a subsidy can be somewhat blurred.

The focus of this study was on the expected effects of a government policy that changes the relative prices of some production factors in the economy. This analysis – and its results – are pretty much the same regardless of whether the policy under analysis is concerned with changing taxes or support measures. The nature of the results are, therefore, equally relevant whether the perspective *a priori* is that there is an inappropriate differentiation of tax rates across sectors involving an unwarranted subsidy that should be abolished, or whether a tax that is seen primarily as a source of revenues for government should be paid either at a reduced rate or not at all by companies that operate under heavy competition on world markets.

In an economy where electricity generation and paper production are sheltered from international competition, a reduction in subsidies (elimination of preferential tax treatment) would be likely to have rather small effects on the environment. This is because the bulk of the cost increase could be passed on to consumers of the newsprint. Only a small share of the adjustment would take place on the production side by different forms of substitution between production factors and the inputs of raw materials.

In a small, open economy context, however, the effects of government measures applied in only one country would have a substantially larger impact on production in that country and, therefore, potentially on emissions. Industrial companies aim to make a reasonable profit given an internationally-set market price for the commodity produced. If profit targets are not satisfied, production will often simply move to other parts of the world where production costs are lower.

Such mobility implies that isolated measures which increase costs in one country can generate important structural effects on the industry and economy in that country. Subsidies to an industry can thus have major effects on the allocation of resources in that country and will, of course, harm the competing industries in other countries.

In accordance with economic theory, this study has taken a marginal approach to its analysis. This means, for example, that the focus was on emissions from marginal units of electricity supply, not on average emissions in the electricity producing sector.

In the case of Sweden, average emissions to the air from electricity generation are very low due to the dominance of hydro and nuclear power plants. Emissions on the margin can, however, be quite high since the last production units in operation in the integrated Nordic electricity market are usually coal- or oil-fired power plants, often in neighbouring countries.

The study highlights the difficulties in predicting the consequences of environmental policy actions both in direction and size. The *a priori* expectation of the research team was that the relatively strict environmental regulations in Sweden would imply that reduced government support or higher taxes on Swedish newsprint manufacturers would lead to larger emissions to the air globally, and also in Sweden, by diverting production to other countries.

Under one set of assumptions applied in this study (the low emission scenario), it was found however that reduced support (or higher taxes) to electricity generation and newsprint production in order to make the Swedish tax system more neutral resulted in a decline in emissions and reduced pollution in Sweden. On the surface, this looks like the kind of policy that could – from a government perspective – generate a win-win outcome, in that it would combine a positive environmental effect with a gain in public sector revenue.

Reflecting on the structural effects on the economy of this kind of policy indicates, however, that the overall costs – at least in the short to medium term – could be very much higher than other available policies which could achieve comparable environmental results. The possible environmental gains are also highly uncertain. In the high emission scenario, the global emissions would increase as a result of the policy.

This indicates that incremental, steady and predictable changes in the policy activities might be advisable in this and other fields, especially in small countries that are highly dependent on international trade. The study also underlines the importance in some areas of not deviating too much from policy arrangements in competing countries.

There is clearly an urgent need for better knowledge of the costs of pollution. The very few studies that are available indicate that the costs of climate change (the greenhouse effect) are about 1-9 öre per kilogram CO_2,[7] *i.e.*, lower than the taxes paid by Swedish industry and much lower than the taxes levied on households and other groups in Sweden. This and other information referred to in this report may be taken as an indication that the assumed target levels for the taxes under examination may be too high. This could mean that there would be net welfare losses from the policy in the long run.

An implication of the analysis is that important advantages could be achieved if countries acted together in their environmental policies, for instance through co-ordinating actions in tax and subsidy policies. This would have a particular bearing on the greenhouse effect which is a truly global problem. In this way, the negative effects of dramatic changes to production in individual countries could also be avoided.

The study illustrates that a solid basis for a properly designed environmental policy requires a great deal of information, including on conditions beyond the national border. Detailed knowledge of policy systems is needed, including regulations, taxes and subsidies, as well as knowledge about production methods, substitution possibilities, marginal suppliers of energy and emission rates. Without this information, it is impossible to calculate with accuracy whether the environmental effect of changes in subsidies or taxes will be worth the costs that may have to be paid for these policies in other dimensions.

Notes

1. See Cline (1992) and Fankhauser and Pearce (1993).
2. This legislation is waiting for approval by the European Community Commission.
3. There are some delivery obligations during the transition period.
4. If they do not have adequate monitoring equipment, they pay the tax according to the sulphur content of the oil used.
5. This model has been developed by EME Analys during 1996 and 1997 for the purpose of forecasting the electricity spot-prices in the Nordic market.
6. Available estimates of price elasticities of Swedish paper production vary from –5 to –99. In the latter case Sweden almost acts like a pure price-taker on the world market (Hultkranz and Wibe, University of Umeå). Cautiously, a price – elasticity in production of –2.5 has been applied in the calculations along with a relatively high price elasticity of –0.5 on Swedish paper consumption. In the closed economy case, these elasticities were of equal size (–0.5). This means a difference of a factor of 5 between the sensitivity of prices in a closed versus an open economy. A price elasticity of –2.5 in an open economy fits with estimates of the sensitivity to changed electricity prices in the electricity intensive industry in Sweden (for example, see E*lpriser och svensk industri*). If price elasticities of the order of –10 had been used in the analysis, the production effects would, of course, have been even higher than those presented. The current calculations can therefore be seen as conservative.
7. Cline (1992) and Fankhauser and Pearce (1993).

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Environmental and Economic Effects of Support to the Austrian Pulp and Paper Industry

by Michael Obersteiner, Sten Nilsson[1] *and* Andreas Wörgötter[2]

1. BACKGROUND AND OBJECTIVES

Around the world, governments offer a myriad of subsidies[3] for different activities – many of which actually weaken economies and harm the environment. Governments, of course, rarely set out to degrade the economy or the environment when they create the subsidies. Rather, they offer most of them with the purpose of stimulating economic development, protecting communities dependent on resource-intensive industries, reducing imports and increasing exports, improving social benefits, etc. However, very often the subsidies currently implemented lead to four undesirable consequences: they increase costs for the government, result in higher taxes which discourage work and investment, fail on their own terms, and hurt the environment (Roodman, 1996).

But, in spite of the above, there are also situations where there are good reasons to subsidise particular activities, providing the subsidies are designed correctly. Real economies never perform as perfectly as in economic textbooks. Short-comings of the market – its imperfections in practice, and its inadequacies even in theory – give cause for government intervention (Sagoff, 1988, and Moore and Stausel, 1995).

Subsidies exist in a wide variety of forms. The most visible are direct government payments that keep prices down for consumers or producers. Subsidies also have less obvious forms that are often more popular with politicians because of their low visibility. But these can be just as costly as direct payments. Many subsidies, for example, show up as general tax breaks. Subtle subsidies also arise when governments sell services and resources for less than they are worth. Another important subsidy (though difficult to calculate) occurs wherever governments take on private risks.

To be effective, subsidies need to be sharply targeted. They should reach only those who are intended to be helped. They should cease when they are no longer needed (the "sun set principle"). Their benefits should justify both their full direct and their indirect costs (Roodman, 1996). Following this, Roodman (1996) has formulated six basic principles for a good subsidy policy (Box 1). The pulp and paper industry (PPI) examined in this study is no exception to the conditions described below.

Box 1. **Six principles of good subsidy policy (Roodman, 1996)**

- Subsidies may be warranted if they make markets work more efficiently, for example, by overcoming barriers to the commercialisation of new technologies over ones with hidden environmental costs.
- Subsidies may be warranted if they advance societal values other than economic efficiency, such as slowing the disintegration of company towns or feeding the poor.
- Subsidies should be effective.
- Subsidies should be efficient: they should directly and exclusively target intended beneficiaries.
- Subsidies should be the least-cost means of achieving their purpose.
- All costs, including environmental costs, should be counted when weighing the worth of subsidies. This entails sometimes-difficult judgements about how to compare different kinds of harms and benefits.

Purpose of the study

This study examines the governmental support (subsidies) awarded to the Austrian PPI. It also attempts to evaluate the impact of the subsidies on the environment and the competitiveness of the industry. In particular, an examination is made of whether the subsidies used led to a cleaner environment and, at the same time, to a more competitive industrial structure. In addition, the point of incidence of the subsidies used is examined in order to determine which types were most successful in achieving these goals. As the paper proceeds, the principles outlined in Box 1 are used as ideal reference points.

At the out-set of this study we tried to use econometric methods to approach the problem, but soon realised that the problem was too complex and that the necessary data collection, if possible at all, would have been far too time consuming. It was thus decided to tackle the problem through an institutional analysis of industrial and environmental policy with respect to all stages of the paper cycle, and to quantitatively compare the subsidy amounts with the economic and ecological performance of the PPI as indicated by available data. The most important messages of the study are illustrated by concrete examples.

2. DIRECT SUBSIDIES AND THE PULP AND PAPER SECTOR

As illustrated in Figure 1, the pulp and paper sector can in theory be influenced by subsidies in many ways.

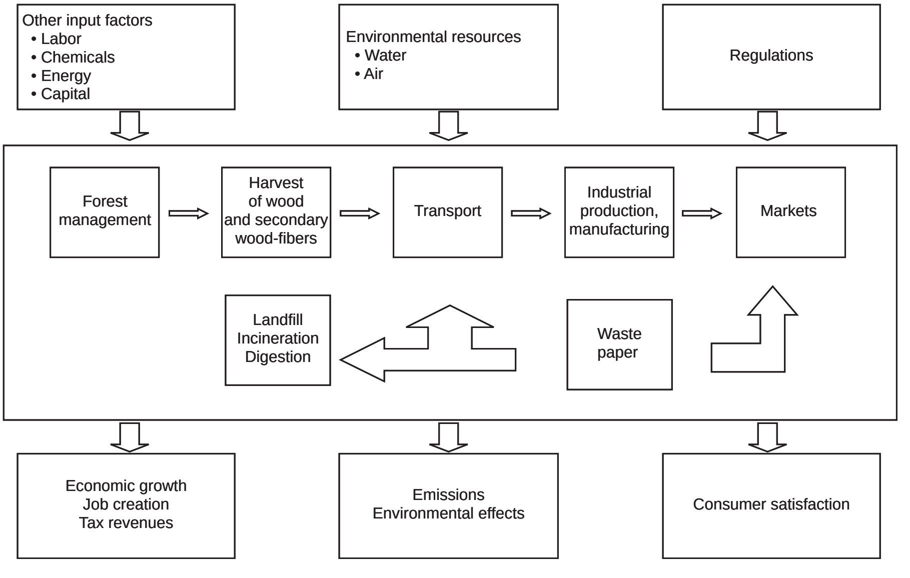
Forest management

Subsidies to forestry in Austria are of minor importance. Federal subsidies to forestry would account for only about 2.6 per cent of those received by the PPI[4] during the period 1984-1996. Subsidies exist to improve transportation infrastructure, to counter the effects of calamities and for reforestation. In addition to federal subsidies, there are also some issued by the individual provinces (Bundesländer).

Wood harvest

In many countries in Europe there has been, and continues to be, support to the annual wood harvest through taxation incentives and direct subsidies. To our knowledge, this kind of stimulation package does not exist in Austria.

Figure 1. **Simplified scheme of the pulp and paper sector**



Source: Author.

In other European countries, it has been found that subsidies to forest management and harvesting are rather inefficient tools for achieving these objectives and, as a result, countries with such packages are increasingly reducing them (SOU, 1992; Göransson and Löfgren, 1986).

Transportation

It is clear that road and railway related revenues do not cover the total expenditures for the transportation infrastructure and fail to internalise all related environmental costs in Austria. Information on support to energy producers (through market price support mechanisms, producer subsidies, and R&D support) is scattered and incomplete in Austria. How the taxation system influences the usage of different fuels and energy prices is also not clear with respect to the PPI. There are, therefore, limited possibilities for examining how subsidies in the energy sector influence the pulp and paper sector with respect to transportation costs.

Industrial production

In the industrial production component of the pulp and paper sector, subsidies are mostly allocated through regional development packages, environmental efficiency packages, or investments in machinery, energy systems, or other input factors. These subsidies are, to a large extent, handled by federal agencies and they are the ones on which the current analysis focuses, largely for data availability reasons.

Markets

Export guarantees do exist in Austria, but the importance of such subsidies to the PPI is rather low since the export share of the Austrian PPI to developing countries is only in the range of 6-12 per cent.

Collection and recycling of waste paper

Historically, direct subsidies have been awarded to support the initial stages of waste paper recycling. De-inking, collection, separation of paper, and the provision of storage facilities have been subsidised in the past by federal, provincial and municipal agencies. Today, there are no subsidies to the waste paper cycle. Instead, a number of market-based regulations have been introduced in order to achieve the desired recycling targets and improve the efficiency of the entire recycling industry.

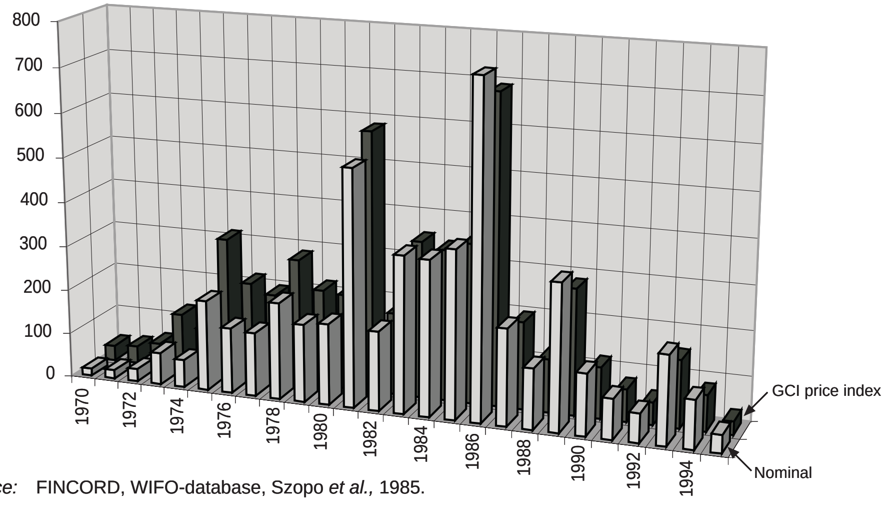
3. EXTENT OF DIRECT SUBSIDIES IN THE PULP AND PAPER SECTOR

In the following, our estimates of direct subsidies by federal authorities to the Austrian PPI will be presented. As discussed above, these estimates mainly cover only industrial production, with the sub-components of regional development, marketing, investments in machinery and energy systems, and environmental efficiency. In the presentation, the study period is divided into two sub-periods, (1970-1983 and 1984-1996). This division coincides with a shift in the administration of the monitoring and data collection of subsidies and the expiry in 1984 of a specially targeted ministerial support program for the PPI. Throughout the study period direct financial support was mostly given through soft loans and interest subsidies by the different funding agencies. The overall results are presented in Figure 2 and Table 1. These estimates are based on detailed calculations, which are presented in Obersteiner *et al.* (1998).

The period 1970-1983

The net subsidies to the Austrian PPI during this period amounted to 2 314.7 million ATS (in current prices). This can be compared with total subsidies to

Figure 2. **Net value of direct subsidies to the PPI in million ATS (real 1983 prices calculated using the gross capital investment price index and current [nominal] prices)**



Source: FINCORD, WIFO-database, Szopo *et al.*, 1985.

Table 1. **Direct net subsidies in Austria, 1970-1996**

Current prices

	1970-1983	1984-1996
	Net subsidies in million ATS	
All sectors*	23 396.3	48 292.8
Industrial sectors	13 100.9	39 772.1
PPI	2 314.7	2 942.3
	Total investments (including subsidies) in million ATS	
All sectors	1 257 638	N/A
Industrial sectors	386 596	680 814
PPI	25 995	55 291
	Net subsidies as per cent of total investment	
All sectors	1.9	N/A
Industrial sectors	3.4	5.3
PPI	8.9	5.8
	Distribution of net subsidies in percentage	
Industrial sectors	48.0	82.4
PPI	10.0	6.1
Mechanical and electric industry	16.9	42.2

* This definition includes the agricultural sector.

all sectors of 23 396.3 million ATS and 13 100.9 million ATS to all industrial sectors. Thus, the PPI received 10 per cent of all money spent on subsidies in Austria and 17.7 per cent of all industry subsidies.

For interest, these allocations can be compared with subsidies to the tourism sector, which is reputed to be heavily subsidised in Austria. This sector received 30 per cent of all the allocated federal subsidies. But the picture is somewhat different if the net subsidies for each sector are put in relation to the total investments (including subsidies) in the sectors. The net subsidies accounted for a significant 8.9 per cent of the total investments in the Austrian PPI, compared with an average of 1.9 per cent for all sectors, 3.4 per cent for all industrial sectors, and 4.4 per cent for tourism.

A dramatic jump took place in the subsidies allocated to the PPI in 1978, when subsidies doubled as a result of the introduction of a new programme (the so-called Zinsstützungsaktion 1978). Subsidies during this period were handled by some 25 different programmes, drawn from about ten different funds. Therefore, it is difficult to get a clear overview of all the subsidies in Austria at this time. One-fifth of all subsidies awarded between 1970 and 1983 by the ministerial programme targeting the PPI were directed toward environmental improvements, mainly focusing on reducing water pollution. The Water Management fund awarded some 2 billion ATS of low-interest loans to the PPI (accounting for 70 per cent of all long-term loans awarded to industry during this period). Other environmental projects started to be subsidised to a greater extent only after 1974/76.

The period 1984-1996

The net subsidies to the Austrian PPI during this period were 2 942.3 million ATS (in current prices). This can be compared with total subsidies to all sectors of 48 292.8 million ATS and 39 772.1 million ATS to all industrial sectors in Austria. The PPI received 6.1 per cent of all money spent on subsidies and 7.4 per cent of subsidies awarded to the industrial sector. Thus, compared to the previous period, the overall industrial sector received a larger proportion of the subsidies. The PPI, however, received a smaller proportion of total and of industrial subsidies in this period, mostly because of increased subsidies to the mechanical and electric industry.

The most important federal funding agencies for the PPI were the Environmental and Water Management Fund (44%), the European Recovery Fund (ERP) (26%), the Ministry of Social Affairs (15%), and a joint Federal-Bundesländer Fund (5%). Interestingly, R&D and "technology" programmes, which were spread over seven different programmes, made up 11.4 per cent of the total funding.

The main environmental focus of the industry and subsidising agencies was still the prevention of water pollution, but air pollution increasingly became an important issue for the PPI as well (see Table 2). Measures for improving waste management are currently increasing rapidly. It is also of interest that some 45 per cent of all investment subsidies had a preventive and efficiency improving goal, rather than end-of-pipe improvements. In the longer term, the former strategies tend to lead to more sustainable (environmentally and financially) solutions than the latter.

Table 2. **Distribution of total expenditures (fixed and variable costs) by the PPI and distribution of awarded investment subsidies (1984 to 1996)**

	Total expenditure	Investment subsidies
Air	19%	42%
Water	68%	48%
Waste	9%	5%
Noise	2%	1%
Other	2%	4%

Source: Water Management Fund, WKO/Austropapier.

The PPI was leading in terms of its relative expenditures on the environment at this time, with some 12.3 per cent of total environmental expenditures in industry taking place in the PPI. Eco-audits were also subsidised for the first companies that volunteered for this scheme.

The period 1970-1996

In addition to these federal funds, the provinces also allocated subsidies, which in many cases were conditional on the contribution by federal agencies. Financial support was also provided through investment tax credits and accelerated depreciation allowances. Accelerated depreciation allowances of up to 60 per cent were allowed for environmental investment projects from 1977 to 1984 and up to 80 per cent until 1988 when accelerated depreciation allowances were finally removed. Financial support to the PPI was also given in the form of a number of indirect measures ranging from subsidised infrastructure provision and debt concessions for public enterprises delivering milling equipment to federal or provincial bodies acting as share holders of PPI companies.

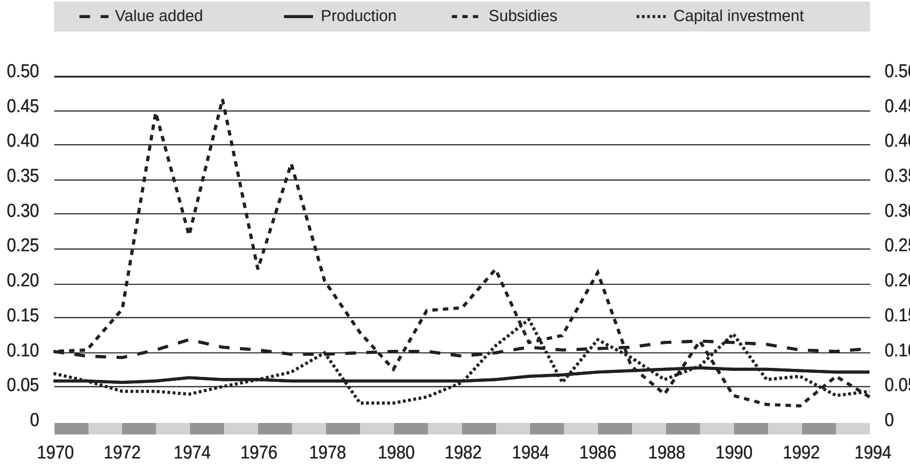
The following characteristics of federal subsidies[5] to the PPI over the period 1970-1996 have been established based on detailed quantitative analyses (Obersteiner, 1998 and Szopo *et al.* 1985):

– Federal subsidies and the statutory tax system made capital cheaper for the PPI:
  - The PPI received more net direct subsidies than other industry branches relative to total investment, total value added and total production output. So from 1970 to 1983 the PPI was the most subsidised industry (excluding state-owned industries) in relative terms. The PPI maintained this status until 1986 and from then on the PPI received less in comparison to the economic performance of the industry aggregate (see Figure 3).
  - The PPI had more subsidies than less capital intensive industries in the form of subsidised capital through tax incentives.
  - Accelerated depreciation allowances for environmental investments supported polluting industries, including the PPI (1977-1988), more than the less polluting industries.

– The higher subsidies did not lead to an expansion of the PPI relative to other sectors as measured by value added and production output. Only from 1984 onwards was the PPI able to expand due to a significant increase in world market prices.[6]

– Productivity, as measured by output per employee, increased more rapidly in the PPI than in all other sectors between 1970 and 1996. The number of workers decreased by 42 per cent over this period. Employment increased by 7.2 per cent between 1986 and 1990 when the sector boomed, but subsidies were low.

Figure 3. **Value added, production, subsidies and investment by the PPI as a share of the industry aggregate**



Source: FINCORD, Szopo *et al.,* 1985, WIFO-database, OECD (STAN).

– Relative to the industry aggregate, the total exports remained constant and at a high level for the PPI, while total imports also increased.

– The PPI made major advances with respect to environmental efficiency over this period – particularly in terms of resource utilisation and emissions. In particular, improvements in the biological state of the rivers were most visible after 1985/86. As a result, the PPI now poses no great threat to the Austrian environment with respect to emissions.

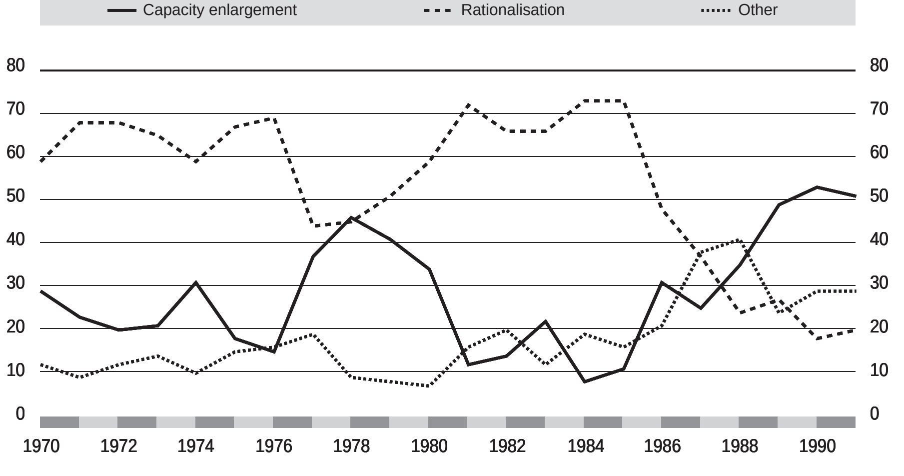
4. SUBSIDY TARGETS AND EFFICIENCY BY DIRECT SUBSIDIES TO THE PULP AND PAPER SECTOR

The subsidies given to the Austrian PPI during the period 1970-1996 had different intended targets. Based on our analysis, we distinguish three main phases. The first phase was between 1970-1983, when growth and job security was the main target of the subsidies. The second phase, 1984-1992, had the dominating target of "green" investments. The third and final phase, 1993-1996, was characterised by a transition to market-based instruments for the subsidy programme.

1970-1983

Economic growth and job security were the main priorities during this period as illustrated by Figure 4. This figure shows that investments were mainly directed towards efficiency improvements and capacity expansion between 1970 and 1983. The strategy at that time was to support the weakest link in the paper cycle, *i.e.*, pulp production. The efficiency improvements not only lowered production costs, but also positively affected the environment. Production processes at the pulp mills were optimised or changed to ensure an improved closure of chemical and water cycles, savings on input factors and a reduction in waste. The necessity for energy saving became apparent during the two oil shocks, and support (subsidy) programmes for energy savings were promptly introduced. Sludge burning and waste water treatment procedures reduced the waste water load by 33 per cent, while pulp production increased by 38 per cent (see Box 2). These improvements were also made necessary because of a number of river restoration programmes first initiated in 1973. During this period, through co-ordinated action and industry-wide planning by the ministerial subsidy programme, four obsolete and highly polluting pulp mills were closed. Nonetheless, the PPI continued to be one of the major polluters to Austrian rivers.

Figure 4. **Capital investment of the PPI by goals (%)**



Source: WIFO-database.

Box 2. **The Lenzing method**

Lenzing is a pulp and paper company located in a traditional Austrian tourist area and whose effluents used to be emitted to a rather small river, Ager. Lenzing used sulphite pulping method, for which there was no readily available technologies for reducing the amount of used liquors, resulting in a biologically dead river. Even in the early sixties, without any regulatory pressure, Lenzing started to burn the solid matter contained in these liquors. This, however, shifted the problem from water pollution to air pollution, which was just as damaging. It became clear that the emitted chemicals (sulphur and magnesium compounds) had to be recovered after the residual organic substances had been burnt. Thus, the so-called Lenzing process was developed in close co-operation with a domestic machine building company. The chemicals were recovered in such a way that they could be reused in the pulping process, and the incineration of lignin and other organic substances generated energy in excess even of what could be used by the integrated paper milling process. At that time, the R&D effort was not given any financial support, but the implementation and further improvements in Lenzing were supported by subsidised long-term credits. This technology was later, under licensing, adopted by a number of domestic (see effect on the energy market in Figure 5 below) and foreign pulp mills.

Between 1970 and 1983, the most important subsidising agencies for environmental projects undertaken by the PPI were ministerial programmes and the Water Management Fund. However, these programmes were introduced under certain conditions, but lacking clear and consistent overall environmental legislation, despite the fact that regulations were sometimes quite tough regarding individual environmental problems. Responsibilities were spread between different federal, provincial, and even municipal agencies. The agencies focused primarily on regulating the emissions which fell under their responsibility, operating almost entirely independently of each other. In spite of the fact that the possible environmental gains of a subsidy programme were questioned, a ministerial programme was established in order to support the pulp industry.

The programme was justified by the need for support because of low world market prices caused by over-capacity, and the urgent need for an environmental up-grading of the production process. The options were to either allow the pulp industry to downsize and substitute the lost production by imports of the required pulp grades, or to massively invest in restructuring. Today, it seems that from a long-term environmental and economic point of view, an alternative use of the subsidies, maybe even implying the additional closure of some mills, would have been more likely to lead to a win-win[7] situation. However, the support programmes were considered at the time to result in a number of potentially positive spin-offs. Roundwood from thinnings could still be economically harvested, which lead to more vital, valuable and stable forest stands and increased employment. Also, sawmilling residues could still be used for pulping,[8] and, finally, the paper industry would be less vulnerable to price fluctuations on the international pulp market. Thus, the considerable amounts of support given to the PPI helped to improve the competitiveness of pulp producers and, through technological upgrading, to reduce emissions from pulp plants.

1984-1992

In the second phase, 1984-1992, the main objective was "green" investments and the ministerial programs were to a large extent phased-out. They were, however, generally substituted by other funds. Environmental subsidies were almost exclusively channelled through the Environmental Fund and the Water Management Fund. Political and public pressure on the PPI led to the introduction of new legislative acts on improved environmental conduct. It was signalled that deadlines for environmental regulations would be strictly adhered to and that even tougher regulations might follow. The earlier focus on control of emissions started to gradually shift to ambient standards. In addition, consumers became increasingly aware of environmental issues and more selective in their product choices.

Given these developments, the Austrian PPI decided to massively increase its expenditures on environmental protection. The environmental goals were so ambitious that introducing simple, end-of-pipe technologies would have been too costly to meet the desired standards. The criteria of the subsidising programmes were flexible enough to allow for environmental improvement through measures that also increased resource efficiency and productivity. The technical solutions implemented included: combined power and steam generation; a shift from coal and oil to sludge, wood residues, and natural gas as combustion fuels; the retrieval of chemicals; the reduction of fresh-water utilisation; and finally, the introduction of scrubbing processes. This lead to the rapid co-evolution of both the PPI and the domestic industries supplying environmentally sound technologies, and resulted in innovations triggered by subsidised joint R&D projects (see Box 3).

Both the PPI and the allied domestic technology industries are today leaders in their international markets. Thus, stricter environmental regulations in a few selected areas did lead to pioneering R&D efforts, which, when designed correctly, can increase industry's competitiveness and help the environment. Support to new technologies not only helped to meet emission requirements, but also lowered operating costs. Nonetheless, compared to the total volume of support, the amount given for innovative solutions was very small. This may be a result of the conditions specified for support and the legislative acts geared towards enhancing environmental performance, which referred almost exclusively to the "Best Available Technology" (BAT).

Box 3. **ÖZF – project**

The Austrian PPI was under pressure to eliminate chlorine as an agent in the bleaching process in the mid eighties. It became apparent that chlorine free (TCF) or elementary chlorine free (ECF) bleached grades were becoming increasingly popular on some of the eco-sensitive European markets. Secondly, the Austrian government announced that it would soon implement tighter regulations on absorbable organo-halogens AOX emissions. BAT was only available to a limited extent because Austria, in opposition to world practice, had adopted the sulphite pulping process where no chlorine-free-technology was readily available on the market.

However, this also meant that the innovation towards TCF bleaching in Austria that took place was able to create world market leadership for this particular technology and for the Austrian machine building industry. This guaranteed the competitiveness of paper producers on the chlorine-free market, and significantly reduced AOX discharges to the recipient rivers in Austria. Chlorine inputs declined from 35 000 tons in the late eighties to almost zero by 1996. A joint research venture between the PPI, the domestic machine building industry and research institutes was able to find the necessary technological solution with the help of governmental research grants, the Environmental Fund and support from some states. As a result, the use of chlorine gas was brought down to almost zero at an impressive pace. In the end, the consumers also benefited from this development, by paying less indirectly than for costly end-of-pipe solutions which also entail high costs for the disposal of the sludge.

1993-1996

In the third phase, 1993-1996, the by-now pooled Environmental and Water Management Fund still continued its operation, and today it remains the most important subsidising agency for environmental projects by the PPI. The fund's criteria were finely-tuned and better targeted programs were introduced. The results are encouraging, with almost all environmental criteria met by all producers.

Because EU regulations forbid certain subsidising practices[9] (*e.g.*, capacity enlargement) and the investment tax credit was lowered from 30 per cent in 1993 to 9 per cent in 1996, more market-based instruments, *inter alia*, laws on the availability of environmental information, participation of stakeholders, eco-audits, packaging ordinances, and energy taxes, have been introduced. In addition, the industry code and some ambient standards were revised. New laws on the use of chemicals, including chlorine compounds, have also been issued during this period. A comprehensive and voluntary "Waste Management Plan for the PPI" was adopted by the industry, the Chamber of Commerce, and the Ministry for Environment, Youth and Family Affairs. Some concrete measures are already on the way to being finalised. On the other hand, deregulation of the energy market has not been implemented as fully as in other countries.

5. ENERGY AS INDIRECT SUPPORT

Above we have discussed the direct federal support to the Austrian PPI, but there has also been considerable indirect support. In the following, one type of indirect support to the PPI will be discussed in greater detail.

The PPI is a heavy energy consumer as illustrated in Table 3 and energy is an important cost component for the PPI. Although pulp and paper accounts for over 4 per cent of estimated global energy consumption (IIED, 1996), the industry's overall carbon intensity is relatively low because it satisfies a large proportion of its energy requirement through burning wood waste (Figure 5). By 1995, the PPI was consuming almost one-quarter of all electricity consumed by industry in Austria. Consumption of electricity by the PPI was increasing more rapidly than the industry aggregate. Since 1990, the PPI has increased its consumption of purchased fossil fuel by 1.2 GJ/t (from 8.8 in 1990 to 10.0 in 1996, see the annex). However, during this period there has also been a shift away from oil and coal towards the less environmentally-damaging natural gas due to federal subsidies. Regardless, the fossil fuel consumption by the PPI has still increased by some 15 per cent during the last six years.

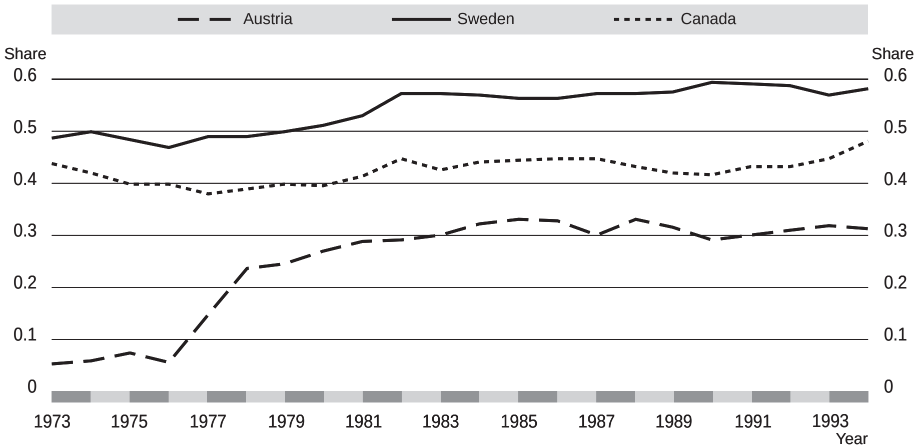
Table 3. **Change in energy consumption of the main non-renewable energy sources by all industries and of the PPI and printing industry between 1970 and 1995**

In percentage

	Industry	PPI	PPI's market share of total industry energy consumption
Petroleum products	–62.3	–43.4	13.1
Gas	81.8	67.1	11.1
Electricity	69.4	145.3	24.2
Coal	–16.7	–37.1	4.6
Total[1]	5.2	95.4	18.7

1. Computed in oil equivalents.
Source: OECD-IEA.

Figure 5. **Share of combustibles, renewables, and waste in total energy consumption by the pulp and paper and printing[1] industries**



1. The printing industry had to be included because of aggregations in the OECD/IEA statistics. Differences in the share of the printing industry and of the pulp industry in the total PPI partially explain the differences in the levels between the countries.

Source: OECD/IEA.

The industry's internally produced electricity increased from 751.9 kWh per ton in 1990 to 936.6 kWh per ton in 1996. The purchased electricity decreased from 472.2 kWh per produced ton to 191.6 kWh/ton during the same time period. This indicates an increase in the overall efficiency of the production process (*e.g.*, through avoidance of transmission losses and power-heat co-generation) and thus also a decrease in the costs to the PPI.

There is still a monopolistic structure in the Austrian energy utilities, which are subsidised, protected and inefficient by international comparison. This structure causes a number of problems, specifically:

– Energy has been, and still is, too cheap in absolute terms in almost all developed countries, largely as a result of the accumulated effects of past support measures and the failure to internalise environmental costs.

– Due to inefficiencies in the energy utility industry and the structure of production and monopoly pricing, the relative price of energy is high in Austria by international standards.[10]

– Prices for deliveries of electricity from the PPI to the public electric network are unjustifiably low, although a least-cost planning scheme would favour such deliveries.

– Due to the structure of the energy prices, the potential use of renewable energy fuel sources by the PPI can only be utilised to a limited extent (today around 40 per cent of the total energy consumption comes from renewable energy sources). Fuel wood, wood waste, waste paper, and municipal waste are potential energy sources (also raw materials), but often can not be used economically for energy production (see Figure 5).

In 1996, a new energy tax was introduced of 0.1 ATS per purchased kWh of electricity and 0.6 ATS per m3 of natural gas. There are a number of drawbacks with this new energy tax:

– All other non-renewable energy sources (oil and coal) are not affected by the new tax. Thus, there is no clear message or incentive for the PPI to switch to renewable energy sources or increase their internal production of electricity.
– At the same time, the PPI receives federal subsidies from the green fund to switch from coal and oil to natural gas.
– Despite the fact that the PPI consumes large amounts of energy, this tax is probably of minor importance with respect to the future behaviour of the industry. Most pulp and paper companies have already reached the maximum taxable ceiling and, therefore, this additional tax will only be paid in select circumstances, so it will not give any incentive to change behaviour in the industry with respect to energy consumption.[11]
– It can also be seen that the reduction of emissions over time, as required by the environmental standards that have been introduced, have been achieved by so-called end-of-pipe solutions, resulting in increased energy consumption.

Future deregulation of the Austrian energy market may change the conditions for the Austrian PPI. Reduced governmental support and/or changed taxes in a deregulated energy supply system (in order to make the tax system more neutral) could result in reduced pollution and cheaper production by the PPI. Support of alternative energy sources or energy efficiency improvement measures, if designed appropriately, could lead to long-term environmental benefits and an improved competitive position of pulp and paper products. The resulting effects on the geographical distribution of production, the requirements for technological innovation, and the substitution effects within competing pulp and paper products are probably the most important areas for further investigation.

But it is also clear that countries have to act together through co-ordinated actions in energy tax and subsidy policies. Normann *et al.* (2000) concludes that the proper design of environmental policies often requires a lot of information on conditions beyond the national border, especially for export-oriented industries. "Otherwise it will be impossible to estimate if the environmental effects of changes in subsidies or taxes is worth the cost that may have to be paid in other dimensions" (Normann *et al.*, 2000).

6. SOME CRUCIAL FACTORS

Austria's small economy has been able to engender priorities in certain sectors through different forms of governmental support. Those policy instruments that have been implemented have been rather specific and the customers were in many cases well known. In the case of the PPI, there are only some 30 producers to be dealt with.

Small, open economies like Austria are strongly exposed to international competition and rely on international policy co-ordination. Changes in the demand pattern for pulp and paper products on the export markets – driven by competitiveness of paper products, environmental concerns, or regulation in other countries – do have a strong influence on the competitiveness of the Austrian PPI and require appropriate adjustments. Because direct and indirect subsidies to the PPI were common in many places in the world during the seventies and eighties, Austria was put under pressure to subsidise its domestic PPI as well.

In order to avoid such a prisoners' dilemma outcome, the extent of support must be comparable across national borders. International comparisons of support systems are generally only sensible if they take the entire regulatory framework into account. Take, for example, the interdependence of direct subsidy payments and the more indirect support that occurs under a favourable tax system. It might be true that a PPI in one country receives (relatively speaking) more direct subsidy payments but is at the same time faced with a more disadvantageous tax system. For instance, capital depreciation allowance rates differ widely across European countries.[12] Austria, especially compared to its direct competitors, is in a rather disadvantageous position, having a capital depreciation allowance rate of 6.6 per cent over 15 years. This must be taken into account in combination with the fact that the investment cycle in the PPI has dramatically changed in the last decades, and today its duration is in the range of seven years with capital investments of several billion ATS. This not only has direct competitive implications for the Austrian PPI, but also deters a more rapid diffusion and more frequent up-grading of new technologies, which (as can be seen in the annex) can lead to considerable environmental improvements. It also inhibits innovation within the PPI, and even more so in the allied chemical and machinery industries. Such disincentives against frequent technological up-grading are difficult to overcome through compensating subsidy programmes, because these, by their nature, do not always reflect the current technological and market needs of the industry.

Historically, subsidies were not used as a proactive policy instrument. The signal of industrial policy to the prospective and clean industry segments were to a large extent missing. Also in Austria, direct subsidies did not focus on a "support the winner" principle during the seventies and eighties, but rather targeted the weakest link in the vertically integrated production chain – *the pulp industry*.

However, subsidies were given out according to a positive selection principle, *i.e.*, to subsidise those enterprises that had higher chances of survival. The opportunity costs of having instead directed the support to other activities of the economy or redirecting it within the paper cycle are difficult to assess. We believe that the chosen strategy was not the best with respect to the long-term strategic goal of a more competitive and cleaner industry structure. However, it was the immediate needs of the industry combined with the prevailing views of real politics that defined the goals of government subsidies at that time. A global optimum of the objective function of the subsidies – to lead, at least in the long-term, to a cleaner economy with a more competitive composition of all industries – should constantly be aimed at, taking temporal adjustment costs into account. An alternative policy, where the polluting industries are allowed to downsize to competitive levels, taking additional environmental investment burdens into account, is – from an economic point of view – much more preferable.

The subsidising of a new pulp mill in Pöls (see Box 4) illustrates how the internal logic of government agencies sometimes leads to such suboptimal outcomes.

In the special case of subsidies for environmental projects, the former argument applies particularly well. Probably the most fundamental criticism of funds supporting environmental investments is that the most polluting industries and enterprises[13] tend to benefit from such programs at the expense of cleaner industries. Thus, such subsidies have a conserving effect on the long-term industrial structure, with competitive implications for the industry aggregate. An environmental project that supports a polluting pulp mill will always, to a large extent, reduce emissions and thus be acceptable under the internal logic of the funds, which mainly aim at technological up-grading to the BAT. The problem is particularly aggravated when subsidies facilitate capacity expansions of polluting and non-competitive industry segments, as illustrated in Box 4. The environmental and economic opportunity costs of such policies are usually large.

However, if we take a perspective where subsidies are aimed at reducing environmental damage world-wide we might come to different conclusions. There are at least two good reasons to argue that polluting industries should be supported to continue to produce in highly developed countries. First, due to stricter environmental standards, the environmental damage per unit of production is smaller. Second, environmental and economic (efficiency) demands in advanced nations accelerate technological change and the location of R&D development is usually geographically clustered around production. Nonetheless, it should be the clean and perspective industries (as opposed to the ailing, dirty industries) which are used to satisfy consumer demand, and that by support measures are targeted to these in order to improve environmental conditions in the long-term.

Box 4. **The Pöls case**

The support of the construction of a sulphate pulp mill in Pöls was probably the most controversial project in the history of subsidy programmes in Austria (Aiginger 1990). It illustrates on the one hand the extent of subsidies and, on the other, provides insight into the internal logic of the subsidy programmes, which led to the acceptance of projects which were undesirable from a more global perspective. After World War II, the mill – with an Italian majority share holder (59 per cent Burgo) – was up-graded with the help of ERP-funds and produced 70 000 tons of sulphite pulp and 13 000 tons of paper. In the mid-eighties, the existing plant had to be replaced for environmental and competitive reasons. A project was then put forward for the construction of a mill to produce 200 000 tons/yr bleached sulphate pulp with an investment of about 2.5 billion ATS. Burgo's share was reduced to 24.8 per cent, with two nationalised companies* holding 64 per cent and the province Steiermark having 11.2 per cent. Initially, the project was subsidised by a 900 million ATS loan from the Water Management Fund at an interest rate of 3 per cent, as well as some support from the province Steiermark, and an additional 900 million ATS by the federal paper industry program at 4 per cent. Later, in order to salvage the mill, one of the share holding nationalised companies had to write off 175 million ATS in debt, special tax concessions had to be made, and another 300 million ATS was allocated from the federal budget. In addition, the debtors had to grant an extension on the repayment period. In the first year of operation (1986), the operative losses were 240 million ATS, largely because pulp prices were at an all time low. Losses continued in the years to come, but decreased because of a rapidly increasing price on the international markets.

As already mentioned, subsidies to the Austrian PPI in the seventies and eighties targeted the weakest link in the paper cycle with the hope that all other industries in the chain would benefit. The justification for this strategic argument did not prove to be valid in the case of Pöls. The sulphate pulp plant attempted to help in the improvement of the Austrian trade balance, rather than to improve the efficiency of the domestic paper cycle. Pöls exported 70 per cent of its output, while Burgo received 40 per cent of the total output at a price 4 per cent below world market price. Only 30 per cent was used by the domestic paper industry. Some 57 per cent of the total material input for the plant (chemicals and machinery with foreign patents) had to be imported since sulphate pulp production was new for the domestic allied industries. Thus, the positive effect on the trade balance of this product with very low value added was rather questionable. In addition, only small amounts of local roundwood from thinnings were used and large amounts, especially of pine wood, had to be imported.

* VOEST held 47.3 per cent and constructed the plant (it was common practice to build reference plants in the home country to improve the export possibilities). The OIAG took over the share that the Ministry of Economics acquired.

Box 4. **The Pöls case** (*cont.*)

Two arguments remain that would justify the project. First, for the local authorities it was important that 500 jobs were preserved in a problem region. Since 1964, over 400 jobs had already been lost. However, under this scheme, the creation of one job in Pöls required five times more investment than the creation of one job in the machine building industry. The second reason can be found in the internal logic of the Water Management Fund, where for good reasons a new plant is always considered strictly better than the continuation of an obsolete and usually highly polluting mill, even if there is a significant increase in output. Unfortunately, the entire project turned out to be so unprofitable that the construction of a biological water treatment facility had to be postponed for some five years after start-up, which led to the continuing heavy pollution of the small river Pölsbach during this period.

Another drawback of subsidies is that there is a strong possibility of a leakage of the subsidies to the construction and banking industry. In the case of green investments, an entire army of consultants that provide the technical expertise necessary for the funding will also benefit from such programs. Their services are sometimes subsidised up to 100 per cent. More generally, subsidies are enormously resource intensive and it is difficult to understand comprehensively the mass of various programmes under all the different funds. The impacts of subsidy programmes on investment patterns, such as through project delays and overall project design of agreed investments, should also not be underestimated. Subsidies for green investments very often lack incentives to further lower overall emission levels if they are not combined with targeted regulations that guarantee such long-term commitments. If such incentives are lacking, the adoption of superior and future compatible technology is inhibited.

Changes in the mode of financing industrial investment projects must also be addressed by changes in subsidy policies. There is a connection between the structure of the capital market and the support system in Austria. Historically, Austria could be described as a credit-based system, with government and domestic banks the major financiers for industrial projects. The state acted as an intermediary, channelling advantageous long-term credits to industry. After 1993, these loans were replaced by interest rate subsidies and existing loans are being sold because of criticism that the government interferes with the banking functions. This system is now on the way to a more capital-market based system, where resources for investment – including environmental projects – can be obtained through the capital market.

A very important aspect of government support is how the strategy building and implementation of support policies are institutionalised. Within the Austrian social partnership framework, the policies were developed after hearing different expert opinions. However, this process generally lacks transparency and does not include all interest groups, which would be required to implement efficient support policies. It seems that strategies could improve if they were *a priori* exposed to more criticism.

The paternalistic character of industrial policies in Austria during the seventies and eighties, was to a large extent dominated by the specific institutions of social partnership in place, clearly favouring the Austrian PPI by allowing for support to establish long-term investment strategies. Due to the PPI's importance on the foreign trade balance and its status within the forest sector, this industry never had serious difficulties in attracting government support. Support schemes were designed with consensual, long-term strategies within the framework of the social partnership, which clearly favoured the efficient implementation of adopted strategies.

These last two points apply to the development of environmental policies in Austria. We have shown that the resulting industrial policy failed for a long time to sufficiently include environmental concerns. During the seventies and eighties, the leading incentives for providing support were growth and job security, while environmental concerns were not formally institutionalised. During this period, environmental instruments usually had a more reactive than a proactive character. It was only when all parties of the social partnership accepted that a clean environment was an important goal that effective instruments for achieving this were implemented. Thus, for any similar process, the long-term goals need to be continuously challenged and adapted to meet new demands.

It can be seen that once a clean environment was recognised as an important goal by the Austrian social partnership, the actions implemented through the subsidy programmes were rather efficient in helping to reduce the environmental pressures of the PPI. Finally, it can be concluded that in the future the most efficient additional improvements in the environmental performance of the PPI should come from market mechanisms rather than from continued subsidisation.

7. REFORM OF THE SUPPORT SYSTEM

As illustrated above, a reform of the Austrian support system for the PPI has already started to take place. The efforts are now more oriented towards the introduction of market oriented mechanisms. But it can also be seen that there is a need to go further with this reform of the current support system. The greatest challenge for reform may not be figuring out what the reforms should be, but in making them a political reality. Subsidies, other policies, and politics are tightly intertwined. The subsidised and the subsidisers come naturally to support one another in a resilient feedback loop (Roodman, 1996), and governments normally have only limited understanding of the overall magnitude of the effects of the subsidies.

A first, basic step in the reform of subsidies is to efficiently document, measure, and evaluate the subsidies that are currently in place and ensure this information is both transparent and publicly available. Having all the relevant information on the support schemes available in a transparent form will probably drive the required reform process.

In Box 1 we illustrated some principles for a good subsidy policy. In addition to these, we would like to stress a couple of important issues that should be taken into account in the reform of the support system. First, the support system should be based on *long-term strategic and clearly defined goals* as a necessary precondition for the *policy co-ordination* of different support instruments. As illustrated in Austria, a consensual policy approach can be particularly successful in the sense that once goals are agreed upon, the instruments implemented tend to readily lead to desired results. But the policies have to be agreed on by the *majority of interest groups*. The *predictability and visibility* of the goals of support systems are of great importance because of the long investment cycles in the PPI. Historically, the Austrian PPI received special attention over a long period, creating a certain predictability in the regulations and public policies that applied to the industry and allowing for long-term strategic planning within the industry.

There is also a need to *harmonise and converge support systems and regulations* in associated fields within the country. Clear long-term goals are a precondition for this harmonisation and it is the *sum of all support instruments* that will lead to substantial impacts. The *institutional set-up* for the support systems is crucial. As illustrated in Austria, for as long as the responsibilities and the administrative powers of the support systems were spread over different governmental bodies, little environmental improvements were achieved, even though particular emission regulations and ambient standards were rather strict. It was only after the Ministry of Environment received sufficient regulatory powers that efficient policies were implemented.

In the case of a small open economy it is also increasingly important to *synchronise* the development of support systems *with other countries*. In terms of environmental regulations, it can prove to be advantageous to try to always be slightly ahead of other countries in selected areas, where the domestic industry is likely to generate the maximal "win-win" outcomes by innovation triggered through targeted support to R&D or market innovation.

Annex

Table A1. **Facts on environmental performance of the Austrian PPI**

		1996	1995	1994	1992	1990	1985	1980
		Use of energy for pulp and paper production						
Fossil resources								
Total	GJ/t	10.0	9.8	9.5	9.0	8.8	10.7	17.0
Natural gas	GJ/t	7.6	7.4	7.0	6.1	5.8	6.0	9.6
Oil	GJ/t	1.2	1.3	1.4	1.6	1.8	3.1	6.0
Coal	GJ/t	1.2	1.1	1.2	1.3	1.3	1.6	1.4
Electricity								
Total	kWh/t	1 128.2	1 159.0	1 163.2	1 213.4	1 224.1	1 219.3	1 387.9
From own power generation	kWh/t	936.6	926.8	888.7	783.2	751.9	799.6	999.3
From external sources	kWh/t	191.6	232.2	274.4	430.2	472.2	419.6	388.6
		Emissions						
Waste water loads with respect to the production of								
Paper and paperboard	m^3/t	15.6	16	16	17	17	n/a	35
Pulp	m^3/t	38.0	44	45	55	65	n/a	85
Average	m^3/t	20.9	22	23	27	30	n/a	55
Total waste water discharges								
Solids	t/a	4 218.5	4 437.8	4 876.3	6 732.0	7 740.0	40 320.0	n/a
COD	t/a	37 013.4	40 021.1	45 757.5	52 452.0	63 648.0	421 200.0	n/a
BOD	t/a	6 468.5	6 833.7	7 485.3	8 316.0	11 772.0	100 080.0	n/a
AOX	t/a	68.2	61.9	229.5	864.0	1 872.0	3 744.0	n/a
Emission of air pollutants								
Dust	t/a	249.5	450	489	553	1 056	n/a	n/a
SO_2	t/a	1 955.2	1 971	2 208	2 600	4 300	n/a	23 000
NO_x	t/a	4 506.7	5 431	5 333	3.6	n/a	n/a	n/a
CO	t/a	996.1	973	800	n/a	n/a	n/a	n/a
CO_2 (fossil)	t/a	2 035.46	1 929.96	2 104.00	1 850.00	1 650.00	1 505.00	1 760.00
Waste materials								
Total	t/a	1 033.779	1 027.08	1 086.739	963.244	963.651	n/a	n/a
Used by other industries	t/a	179.553	170.009	144.846	68.637	n/a	n/a	n/a
Burned	t/a	610.388	583.746	589.238	502.239	485.078	n/a	n/a
Land fill	t/a	239.15	271.199	350.312	387.141	363.146	n/a	n/a
Other	t/a	4.688	2.126	2.344	5.227	115.427	n/a	n/a

Source: AUSTROPAPIER 1997.

Table A2. **Industry specific facts for the Austrian PPI**

	1996	1995	1994	1993	1992	1991	1990
Number of mills	30	31	31	30	32	33	33
Output ('000' t)							
Paper and paperboard	3 653	3 599	3 603	3 301	3 252	3 090	2 932
Pulp	1 206	1 23	1 196	1 078	1 113	1 109	1 107
Mechanical pulp	344	390	399	375	376	371	353
Roundwood inputs ('000' CUM)							
Coniferous	2 374	2 569	2 473	2 454	2 36	2 443	2 438
Deciduous	883	823	808	871	985	981	1 021
Secondary wood fibre	2.97	2 907	2 838	2 352	2 545	2 442	2 397
Total	6 227	6 299	6 119	5 677	5 89	5 866	5 856
Imported (%)	29.3	34.3	35.0	33.0	32.3	32.2	27.1
Waste paper used ('000' t)							
Total	1 537	1 442	1 405	1 274	1 272	1 184	1 143
Imported (%)	38.5	40.1	35.0	34.6	47.3	46.5	51.6
Turnover (%)							
Domestic	18.6	19.3	20.7	20.9	22.0	23.1	23.9
Export	81.4	80.7	79.3	79.1	78.0	76.9	76.1
Share of total exports (%)	5.4	4.8	4.8	4.7	4.9	5.2	5.3
Number of employees	10 132	10 324	10 445	10 701	11 536	12 079	12 287
Investment (Billion ATS)							
Environment	1.43	1.58	2.82	2.16	2.1	3.03	2.17
Total	4.75	3.04	2.94	3.26	5.04	6.86	6.72

Source: AUSTROPAPIER 1997, 1992.

Notes

1. Head of the Forest Resources Project. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.
2. Head of the Economics Department. Institute for Advanced Studies (IAS), Vienna, Austria.
3. In this study, a subsidy is defined as a government policy that alters market risks, rewards, and cash in ways that favour certain activities or groups.
4. The definition of the pulp and paper industry used here includes producers of pulp and manufacturers of paper products.
5. Note that the support given by provincial governments is not taken into account in this analysis.
6. If we compare growth within the PPI in Austria we find that in nominal terms output in the paper and paperboard industries increased more than twice as fast as the pulp industry between 1970 and 1996. In comparison to the two major resource-rich competitors, Sweden and Finland, the Austrian paper and paperboard nominal output grew faster between 1994-1996 than the others, by some 12 per cent and 7 per cent respectively, but lagged slightly behind during the period 1970-1983.
7. It is crucial to realise that, at that time, the principle goal of subsidies was not to achieve a win-win strategy. The overall principle was a more abstract social goal, which included environmental considerations but not commercial goals. From a political point of view, the awarding of public financial resources to industry for commercial goals could not be justified.
8. Note that the import share of wood fiber is in the range of 30 per cent today.
9. The proposed construction of a lyocell plant in Upper Austria with the support of heavy federal and provincial subsidies had to be canceled due to EU intervention. Ironically, EU subsidies have supported the construction of the plant in a different province, which have led to losses in technological and energy synergys, and an increase in transportation.
10. In the case of electricity, a comparison with Sweden and Finland shows that industrial users (> 10 GWh) in Austria paid almost twice as much as their competitors in July 1997.
11. Calculations by Hess *et al.* (1997) show that from a theoretical level of 119 million ATS, only 3 million ATS of tax revenue wouldactually be collected due to the tax ceiling. The new tax reform will have to take these facts into account.
12. Capital depreciation allowance rates vary between 5-30 per cent, with durations of between 5 and 25 years allowing for either straight line or reducing balance depreciation and additional allowances against taxation.
13. In the period from 1970 to 1984, 70.7 per cent of all loans of the Water Management Fund allocated to industry were distributed to the PPI.

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Competitiveness and Reduction of Support Measures to Industry: the Prisoners' Dilemma

by Harmen Verbruggen *and* Frans Oosterhuis

1. INTRODUCTION

The interest in the possible negative environmental consequences of various kinds of financial support measures has recently led to a lot of activities. Recently, studies on this subject were published by the World Watch Institute[1] and the Earth Council.[2] The OECD is also devoting attention to the harmful impacts which subsidies may have on the environment, and, in addition, is addressing the question of which internationally coordinated strategies to reduce the impact of these measures seem most feasible.

Within the framework of a wide-ranging OECD study on subsidies and tax incentives with an adverse effect on the environment, the present paper deals with the effects of the reduction of support measures on competitiveness. It aims at highlighting the "prisoners' dilemma" countries face that seek to reduce support measures to industries that produce internationally traded products. This "prisoners' dilemma" arises because, although it may be in the interest of all parties to abolish environmentally harmful subsidies, a single country taking the initiative to do so may negatively affect its industry's competitiveness if other countries do not follow suit. The paper thus has an international focus: it addresses those subsidies which are considered to be essential for a country's competitiveness on the world market for tradable goods.

This paper will not enter into the ongoing discussion on what actually constitutes a subsidy [see, for example, Gerritse (1990), OECD (1996*a*)]. It will take a pragmatic position instead, and address mainly the forms of financial government support which directly lower the costs or increase the revenues of an industry based on the consumption or production of particular goods. Another thorny question is to determine what subsidies can be qualified as environmentally malign. Not all subsidies to industries or activities which contribute to environmental problems are necessarily environmentally harmful. Energy subsidies (by way of preferential electricity rates) to, for example, the aluminium industry could be considered environmentally damaging. However, at the same time such subsidies reduce the production cost of a material which, due to its low weight, may lead to reduced energy consumption if it is substituted for steel (for example, in cars). On the other hand, not all environmentally motivated subsidies, or subsidies such as the aluminium one which might appear to have an environmental benefit, can be regarded as truly environmentally beneficial. As has been pointed out by Baumol and Oates (1979), subsidies based on pollution reduction will lead to lower average costs of production, and thus lead to increases in output of the polluting industry in the long term. Moreover, such subsidies are generally incompatible with the Polluter Pays Principle and thus may create trade distortions. Finally, environmental subsidies may be disguised forms of supporting inefficient domestic industries (*cf.* Verbruggen, 1990). So, there are environmentally "good" and "bad" subsidies.[3] Whether a subsidy is "good" or "bad" is not always easy to tell. It depends, of course, also on the reference situation: removing environmentally harmful subsidies will not only lead to lower production levels in the polluting (formerly subsidised) industry, but also to a growth in other activities due to income and substitution effects. The present paper will not deal with these issues.

In order to link with other parts of the wide-ranging study, the paper focuses on agricultural products, ferrous and non-ferrous metals, energy carriers and paper. Furthermore, it pays particular attention to variations in the severity of the prisoners' dilemma in these different sectors, depending on the nature of competition (price and cost competition as compared to quality competition). Some attempts are made to quantify the differences in effects of support measures on competitiveness. The paper also aims to identify promising implementation strategies for countries that wish to reduce their support measures. Finally, some suggestions for further work are given.

The outline of this paper is as follows. Section 2 addresses the question of whether, and to what extent, the removal of environmentally harmful subsidies constitutes a "Prisoners' Dilemma" in international trade. In Section 3, a brief summary is given of the main types of subsidies and tax incentives which are currently applied to agriculture and to the metal, energy and paper industries in OECD countries. A sketch of the cost structure and market situation characterizing these industries is also presented. In Section 4, some attempts are made to assess the impact of reducing subsidies on international competitiveness. Possible strategies for countries seeking to reduce environmentally harmful subsidies without harming their economies are discussed in Section 5. Section 6 presents conclusions and some suggestions for future work in this area.

2. THE PRISONERS AND THEIR DILEMMAS

"Prisoners' Dilemma" (PD) is the common term for a strategic game in which two players would both be better off if each of them followed a cooperative strategy. Nevertheless, under the assumption of self-interest and a lack of communication, each of them chooses a non-cooperative strategy. It can be illustrated by the following payoff matrix (adopted from Blackhurst and Subramanian, 1992):

		Player B	
		C	NC
Player A	C	3, 3	1, 4
	NC	4, 1	2, 2

The payoff matrix shows that if both players follow the cooperative (C) strategy, they both receive a payoff of 3 units. If both act non-cooperatively (NC), the payoff to each of them is 2 units. If A follows a non-cooperative strategy and B a cooperative one, the payoff to A is 4 and to B is 1, and *vice versa*. The reasons for A to choose the non-cooperative strategy are:

- the *fear* that, if B takes the NC strategy, following the C strategy would leave A with a payoff of only 1;
- the *hope* that, if B takes the C strategy, A would get a payoff of 4 if it chooses the NC strategy.

B will of course have similar considerations, so that both players will choose non-cooperation and end up with a payoff of only 2 units each, even though a cooperative solution would have yielded 3 units to each of them.

Prisoners' Dilemmas typically arise in the area of public goods. Here, the "C" strategy is the voluntary contribution to the public good. As the PD makes such voluntary contributions unlikely to come about, governments usually take responsibility for the provision of public goods and finance them through obligatory contributions (such as taxes). However, at the supranational level no such government exists. As a result, PDs tend to persist in situations where several countries would all be better off if each of them behaved cooperatively, but no single country has the incentive to do so. International negotiations are then necessary to overcome the PD. Moreover, an enforcement mechanism (*e.g.*, trade sanctions) will be needed to ensure all participants abide with the agreement and do not behave as "free riders", benefiting from the cooperation of the others while not cooperating themselves.

In practice, "pure" PDs are rare in international relationships. As will be shown below, unilateral action may well produce a net gain for a single country, even if other countries do not co-operate. On the other hand, a strategy which, if followed by all countries, would increase global welfare, may well leave some countries worse off. These countries have no interest in cooperating. In such cases, several solutions are conceivable which still may lead to a cooperative strategy:

– "*issue linking*": the scope of the agreement is widened to include issues in which the non-cooperative countries have an interest as well;

– *side payments and/or sanctions*: the cooperating countries decide to bribe or punish the non-cooperative ones; or

– "*leadership*": one or more countries which have a particular interest in the issue conclude an agreement.

Other countries may decide to follow or remain "free riders". Such a solution is only possible if the payoff to the "leaders" is high enough to make them prefer the cooperative strategy, even if several other countries act non-cooperatively.

For the purpose of the present paper, it is of interest to find out whether and to what extent the removal of environmentally harmful subsidies constitutes a "Prisoners' Dilemma". A situation constitutes a "pure" PD if two conditions are fulfilled:

1. a single country taking the initiative on its own would suffer a welfare loss; and
2. a collective international action would leave all countries involved better off.

A situation in which condition (1) is fulfilled, but condition (2) is not (*i.e.*, a collective action improves global welfare but still reduces welfare in one or more countries) will be called a "Pseudo Prisoners' Dilemma" (PPD).

We will now look at the two conditions for a (P) PD subsequently.

1. Does unilateral subsidy removal lead to a welfare loss in the country taking the initiative?

A clear distinction should be made between governments as players in the international arena (presumably aiming tomaximise social welfare in their country) and the various individual players within a country, who will often have opposing interests.

The question of whether reducing subsidies unilaterally in one country will reduce that country's welfare depends on the nature of the international market. If it is a purely competitive market, the subsidy reduction in Country A will not lead to a change in world market prices. Assuming an absence of any market distortions (other than the subsidy itself)[4] in Country A, the allocative efficiency will improve and A's overall welfare will increase rather than decrease, *even if all other countries* *maintain their subsidies*.[5] In other words: in the case of a relatively small country which cannot influence world market prices (nor other countries' subsidy policies), unilateral subsidy removal will be an economically rational decision, regardless of what the rest of the world does. Only in a situation where a country's policies do affect the world market (as is, for instance, the case with the EU's agricultural policy), will the production decline of the formerly subsidised industry in Country A lead to price increases on the world market. This will provide "windfall profits" to foreign producers (in addition to the subsidies which they continue to receive) at the expense of producers and consumers in Country A.

Given the fact that in most cases even the unilateral removal of environmentally harmful subsidies would increase overall welfare of a country, one may wonder why such subsidies nevertheless tend to be so persistent. The explanations which can be found for this phenomenon usually have a political-economic or "public choice" character. Anderson (1995), for example, points to the fact that policies which assist particular groups are a way for governments to obtain political support. He states that the policies most likely to be observed are those that deliver large and concentrated benefits to well organized groups and which impose costs on other less organized groups in a dispersed way so that each loser only loses a little. Similarly, Burton (1983) concludes that the costs of support to enterprises can be made relatively invisible in mature economies with a wide tax base and numerous sources of taxation: the wider the tax base, the larger the number of taxpayers and the more difficult it becomes to organise a lobby to oppose the growth in subsidies. Roodman (1996) cites several examples of monies paid by companies to politicians (in the USA and elsewhere) in order to safeguard subsidies and tax breaks for resource depletion.

Subsidies to producers do not always stay in the recipients' pockets. In a "buyers' market", the subsidy will be shifted onward to the customer.[6] Therefore, it is not necessarily the intended recipient of the subsidy who has the main interest in maintaining the support. Generally, subsidies will show a tendency to "leak away" to those actors with the strongest (market) power. Not surprisingly, these actors are often also the ones with the strongest lobbies and therefore have a good chance of ensuring the continuation of subsidy schemes effectively. On the other hand, there are several groups of actors who would benefit from the removal of subsidies to producers, but do not pursue their interests as fiercely: taxpayers, producers of non-subsidized substitutes, consumers, unemployed people,[7] and (in the present case of environmentally harmful subsidies) all those who suffer from the ensuing environmental degradation.

Another possible reason for the persistence of industrial subsidies can be found in the alleged positive external effects for which they are sometimes considered to be a compensation. In other words, when the absence of a subsidy would not lead to the above mentioned distortion-free market, but instead to the continued existence of uncompensated "external economies". In general, three kinds of motives for subsidies to industry can be found in the literature:

1. *the "infant industry" argument*: giving a (temporary) subsidy for emerging industries, especially in the developing world, is often considered to be justifiable because in their initial stages of development such industries are often not able to compete on the world market, even if they have a comparative advantage in the long term;
2. *the "internal economies of scale" argument*: some industries (*e.g.*, the aircraft manufacturing industry) are characterized by almost unlimited economies of scale. Without government support to competing firms, world production would be dominated by only one or a few companies, seizing market power and thus negatively affecting global welfare;
3. *the "cluster" argument* (*based on the work by* Michael Porter): this argument points at the important role of inter-industry networks for international competitiveness. The creation of such networks would imply external economies, calling for government support.

Whatever the merits of these three arguments may be, it seems clear that they do not apply to subsidies provided to mature or declining sectors, nor to general subsidies to inputs such as energy.

In short, in the majority of cases the abolition of distortionary subsidies will increase a country's welfare, even if applied unilaterally. Only when a country's actions have an influence on world market prices, might its net welfare decrease as a result of unilateral subsidy removal. But even if overall welfare would increase, the political influence of the potential losers may outweigh that of the winners, thus making politicians *believe* that a unilateral subsidy removal would be economically harmful. This type of (unwarranted) fear of a "first mover disadvantage" creates the impression that the first condition for a "Prisoners' Dilemma" is fulfilled, whereas in reality it is not.

2. Does collective subsidy removal lead to welfare gains in all (or most) countries?

When subsidies are reduced simultaneously by all countries, one may expect that this will normally lead to welfare gains for most of them. Provided there are no other major market distortions, the allocative efficiency in the countries which used to subsidise their industry will improve, and their aggregate welfare will increase. When subsidies to *outputs* are removed (usually accompanied by a removal of other protectionist measures), the competitive position of countries specialising in the export of that good (and which did not apply subsidies before) will improve. Only those countries which have a strong comparative disadvantage for the production of the good, and therefore are "deemed" to be importers of it, may be net losers if they are confronted with higher prices on the world market. However, this loss will only be serious if the supply on the world market is inelastic. Likewise, if subsidies to inputs are removed, countries which are net exporters of those goods may suffer a net welfare loss, but only if the demand for these inputs on the world market is inelastic.

Some empirical indications of the impact of subsidy reform on net economic welfare can be derived from the available literature, although usually at an aggregated level of regions, rather than a country specific level.

For example, Anderson and Tyers (referred to in Anderson, 1992) have estimated the effects of liberalising world food markets. Taking 1990 as a reference year, they concluded that removing protectionist food policies in the advanced industrial countries would lead to an increase in annual net economic welfare of US$62.4 billion for the world as a whole.[8] The only countries which would experience a net welfare loss would be South Korea, Taiwan, and the countries of Northern Africa and the Middle East. If the developing countries would reform their food policies as well, the welfare increase would be US$106.5 billion per year, with only a (small) welfare loss for North Africa and the Middle East. Hence, food subsidies seem to represent an almost "pure" PD situation, at least at the level of regions. This suggests that there might be scope for further reforms, beyond those agreed upon in the Uruguay Round of the General Agreement on Tariffs and Trade (GATT).

Similar calculations have not been found for the other sectors covered by this paper. However, it seems obvious that reforming coal subsidies would also imply a welfare gain for all countries involved. Countries which presently support their coal mining industry would be better off, due to improved allocation and lower prices for coal users. Coal exporting countries would be able to reap welfare gains by getting access to new markets. And third-party countries would be largely unaffected: coal prices on the world market would hardly increase as a result of the additional demand from former subsidising countries, given the high price elasticity of international coal supply in the long run (Radetzki, 1995).

It should be added that the welfare effects mentioned here do not include the changes in welfare due to the environmental impacts of subsidy reduction. The assumption of this paper, as stated in the introduction, is that the overall environmental impacts of subsidy reduction are positive. Nevertheless, this overall impact may be the net result of positive and negative effects. The distribution of environmental effects could be such that some countries suffer a net welfare loss. An example could be an increase in landscape destruction due to a potential growth in coal mining activity in (say) Australia, induced by the removal of European coal subsidies. It is impossible to say beforehand whether such negative welfare impacts would offset the welfare gains from production increase.

We can thus conclude that as a result of reducing environmentally harmful subsidies the number of countries which will enjoy net benefits is likely to be (much) larger than the number of countries suffering a welfare loss. The second condition for a "(Pseudo) Prisoners' Dilemma" thus seems to be fulfilled, and it should in theory be possible to solve it by means of international cooperation, possibly including some of the measures mentioned above to induce any potential "losers" to participate.

However, things look different when we take into account the *perceived* welfare losses due to subsidy reduction, as described above. The second condition for a PD situation would then be that the politicians are convinced that an internationally coordinated subsidy removal would *not* harm their economies (read: the actors presently enjoying the benefits of the subsidy). This may be true in some cases, but certainly not everywhere. For example, in the study by Anderson and Tyers mentioned above (Anderson, 1992) agricultural subsidy reform led to substantial production decreases in Japan's and Western Europe's agriculture. This is a logical result of abolishing market distortions: production will shift to countries with a comparative advantage for the product in question. Similarly, removing energy subsidies to energy intensive industries will favour countries with cheap energy resources (*e.g.*, hydropower). Therefore, although an internationally coordinated action will be less detrimental to industries losing their protection than unilateral initiatives, additional benefits for these industries are needed if the final outcome is to appear a "win" state for all countries involved. For this reason, governments tend to look for new types of aid, such as direct income support and other subsidy schemes which are not directly related to output levels, to compensate their industries.

In concluding this section, we can state that the removal of environmentally harmful subsidies usually does not constitute a real Prisoners' Dilemma for countries seeking to maximise social welfare. Unilateral initiatives will be the optimal strategy in many cases, regardless of the behaviour of other countries. However, the *perceived* welfare losses from unilateral actions may well lead countries to abandon such actions. While coordinating the subsidy removal internationally would be likely to turn some of these countries into (perceived) winners, it will not always do so. A feasible solution may then require the implementation of compensating measures for the actors who would otherwise still be losing, even under the collective strategy.

3. SUBSIDIES, COST STRUCTURE AND MARKETS IN THE AGRICULTURE, METAL, ENERGY AND PAPER INDUSTRIES

This section presents some basic information on the four focal sectors of this paper: agriculture and the metals, paper, and energy industries. This information may be useful background information when assessing the impact of subsidy removal on international competitiveness and the extent to which a "prisoners' dilemma" actually exists in any of these sectors. Section 3.1 gives a brief survey of government support to these sectors in OECD countries. Section 3.2 surveys their main features in so far as they may be relevant for international competitiveness.

3.1. Subsidies

The four economic sectors which have been selected all make products which are internationally traded, but they differ in the extent to which they receive subsidies or other forms of protection to improve their competitive position on both the domestic and the world market. As it is impossible to enumerate all of the kinds of support which these sectors receive, this section presents a few characteristics of the main types of subsidy in use and tries to assess their features in terms of the point of application (inputs, products, or income/value adding factors) and relative importance (in relation to total production value).

3.1.1. *Agriculture*

Agriculture stands out as the main recipient of direct government support in many OECD countries. For example, in 1995 the European Union spent about half of its 75 billion ECU budget on agricultural market interventions and export restitutions (Europese Commissie, 1996). This share was even higher in the past: it has been reduced following the Uruguay Round agreements. Moreover, the nature of the price support has changed. A major part of the EU's agricultural support is now de-linked from production levels (*i.e.*, direct price support) and relates instead to parameters such as the amount of hectares (with an obligatory percentage fallow), the number of livestock, etc.

The OECD has developed the Producer Subsidy Equivalent (PSE) as a standardised measure of support to agricultural producers. In 1996, the PSE for the OECD as a whole was estimated at US$166 billion or 131 billion ECU. As a percentage of the total production value, the PSE decreased from 45% in 1986-88 to 36% in 1996. The composition of support has also changed. Market price support fell from 65% of total support in 1986-88 to 59% in 1996. Direct payments increased from 18% to 23%. Other budgetary support (mainly subsidies to inputs and general services benefitting the agricultural sector as a whole) remained fairly constant at 17-18%. Among the support schemes based on direct payments are those with environmental compliance requirements (OECD, 1997*b*).

The level of agricultural support differs widely among OECD countries. The largest subsidies, in relative terms, are given in Switzerland, Norway, Japan and Iceland; the smallest in Australia and New Zealand.

3.1.2. *Metal industry*

Ferrous metals

This industry includes the mining of iron ore (NACE 13.1), the manufacture of iron and steel, the manufacture of steel tubes, and the first processing of steel (belonging to NACE 27).

Until recently, government support for the steel industry was significant in many parts of the world. State ownership and financial assistance were commonplace. Since the mid-1980s, however, privatisation programmes have been implemented, supplemented by the reduction or elimination of subsidies. Since that time, public money in the OECD (and especially the EU) countries was largely directed to easing the restructuring process and overcapacity reduction in the steel industry. The 1992-1994 annual average state support by EU governments to the iron and steel industry amounted to 970.1 million ECU. The Europan Coal and Steel Community provides support of some 200 million ECU per year. Together, these subsidies amount to about 1% of the EU's total production value or 8% of value added.[9] Most of this is probably unrelated to current production activities, but is instead aimed primarily at restructuring.

Non-ferrous metals

This industry includes the mining of non-ferrous metal ores (NACE 13.2) and the production of various non-ferrous metals (NACE 27.4). In terms of production volume, the main non-ferrous metals are aluminium, copper, zinc and lead.

Information on subsidies for the non-ferrous metal industry is scarce. The main way for governments to provide financial support to this industry (in particular the energy intensive aluminium industry) is through favourable energy rates. Koplow (1996) states that "primary aluminium production around the world receives heavily subsidised electricity", but does not give any details. According to Roodman (1996), "aluminium smelters tend to congregate around sources of subsidized power, putting alumium recycling at a disadvantage". However, the existence and size of such subsidies is often hard to prove. Usually, the contracts between energy producers and large energy users are secret. One example of (cross-)subsidies to the aluminium industry is the case of Aldel and Pechiney in the Netherlands. In 1993, their energy price was cut by 25% in order to enable them to cope with economic depression and foreign competition, in particular from Eastern Europe (ECN, 1994). Given the fact that energy costs make up about one third of the production costs of aluminium, the implied subsidy in this case was some 8% of production costs.

Andrew (1996) mentions, in addition to energy pricing, a number of other types of subsidy which have been used in this sector, including injections of capital through the budget, non-market related interest rates on loans, buy-up of debt, state guarantees on loans, as well as depletion and other taxation allowances. Government support for research and development may also affect the competitiveness of the industry. No attempts at quantifying these subsidies have been found.

3.1.3. *Energy*

Financial support favouring the energy industry is quite common in most OECD countries. Typical examples of such subsidies include the following (IEA, 1996; OECD, 1996*c*; Roodman, 1996; Ruijgrok and Oosterhuis, 1997):

Subsidies for domestic coal production

These subsidies are substantial in a number of OECD countries; in particular in Germany, where the Producer Subsidy Equivalent for coal amounted to US$6.9 billion in 1995 (US$119 per tonne of coal produced, which is more than 50% of the price of coal tor industry and electricity generation). Although coal subsidies in the OECD are declining, they are still sizable. Their complete removal is estimated to offer a large potential for the mitigation of greenhouse gas emissions, of the order of hundreds of millions of tonnes of CO_2 per year by 2010 if implemented throughout the FCCC Annex I region (Michaelis 1996).

Preferential (tax) treatment for exploration and exploitation of domestic energy sources

Many OECD countries offer tax reductions or exemptions, interest free credit and other kinds of subsidies for oil and gas exploration activities in their territories. Several countries also offer "royalty holidays" and/or corporate tax reductions to stimulate domestic production of oil and gas.

Investment subsidies for energy infrastructure

A large part of these subsidies is intended to promote energy efficiency or to stimulate the use of renewable energy sources.[10] Substantial investment subsidies are also provided by the European Union for the extension of transnational gas networks and power grid connections within the Trans European Networks and Interreg II programmes. Through its Structural Funds, the EU is also involved in subsidizing several fossil-fuel power plants. Likewise, the Japan Development Bank grants construction loans on favourable terms for power plants using fuels other than oil.

"Soft loans", low profitability and tax exemptions for state-owned/monopoly energy companies

Many energy companies which are state-owned or have a (legal) monopoly have access to credit at relatively favourable conditions, due to the absence of commercial risk. Returns on investment may also be structurally low or even negative in state-owned companies. Quantification of implicit subsidies like these is almost impossible. Public utilities are often also exempt from corporate taxation.

Estimates of total support for the energy industry differ widely, depending on what is included in the definition of a subsidy and the method used to calculate implicit subsidies. Ruijgrok and Oosterhuis (1997) arrived at a yearly amount of direct subsidies of almost US$15 billion (11 billion ECU) for the energy industry in the EU. The production value of the EU's gross inland energy consumption can be roughly calculated at some 150 billion ECU,[11] so the subsidies account for roughly some 7% of production value. Estimates for total energy subsidies in the USA range from US$5 to US$80 billion per year (Toman, 1996), or 2 to 27% of the value of gross inland consumption of energy.[12]

3.1.4. *Pulp and paper industry*

Details about the extent to which the pulp and paper industry receives subsidies are lacking. Some types of support which benefit this industry are (see, *e.g.*, Kerski, 1995):

- logging concessions at favourable terms;
- free use of road infrastructure opening up forests;
- development aid benefitting domestic pulp and paper industries investing in developing countries;
- low rates for inputs such as water and energy; and
- tax reductions and exemptions (*e.g.*, energy taxes).

In addition, one could mention the (financial and regulatory) support which is given to paper recycling. Although this is obviously intended to be an environmentally beneficial kind of support, the financial part of it also lowers the production costs for paper in general, thereby increasing demand (*cf.* Section 1). It also has a major impact on the trade in virgin materials, regardless of the relative environmental benefits of the production process.

3.1.5. *Conclusions*

Table 1 summarizes the information given in this Section by presenting the main features of government support to the four sectors, their importance and the main points of application.

Table 1 shows that among the four sectors examined,agriculture seems to be the main beneficiary of subsidies. It should be added, however, that the level of support for the metal and pulp and paper industries has not been assessed as thoroughly as for agriculture and energy. Regarding the points of application, the picture is mixed: inputs, outputs and value adding factors are all used as a subsidy basis. A shift from output related subsidies towards income support ("decoupling") can be observed in the case of agriculture.

Table 1. **Subsidies by sector, importance and point of application**

	Importance (% of production value)	Main points of application
Agriculture	Varies widely between countries; OECD average 36%; but currently decreasing	Mainly output; shift in emphasis towards income
Metal industry	Steel: ± 1% in EU; aluminium possibly higher	Steel: value adding factors (capital); aluminium: inputs (energy)
Energy industry	Overall: ± 7% in EU; much higher in some cases (*e.g.*, German coal)	Coal: output; others: value adding factors
Pulp and paper industry	Unknown; probably only important in countries with large forestry sector	Inputs (wood, energy, water)

3.2. Cost structure and market situation

In order to be able to assess the impact of subsidy removal on international competitiveness, it is useful to have some information on the factors which determine the industries' international competitiveness in general.

Table 2 presents a summary of the main features of the cost structures which characterize the industries analysed in this paper. It shows the relative importance

Table 2. **Main features of cost structure by sector**
In OECD countries

	Agriculture	Metal	Energy*	Pulp and paper
Capital intensity	Moderate	High	High	High
Labour intensity	High	High	Low	Moderate
Energy intensity	Moderate	High	High**	High
Water intensity	High	High	High	High

Note: The data used for compiling this table are for the Netherlands (Source: Centraal Bureau voor de Statistiek). Capital stock and labour employed are related to gross value added, while energy and water use are related to production value in each sector. A 'low' intensity means less than 75% of industrial average; "moderate": between 75% and 125%, and "high": above 125%. Energy intensity will probably be low(er) in other OECD countries (in the Netherlands horticulture is a significant gas user). Capital and (fossil and nuclear) energy intensity are probably also lower than indicated for 'low-input' agricultural practices (such as organic farming) and for renewable energy.

* Excluding cooling water.

** The energy intensity of energy production is, of course, very high if one includes all energy inputs in the production process. If the energy incorporated in the final product (*e.g.*, petrol) is subtracted, it is still high for many parts of the industry (*e.g.*, refining, electricity production).

Table 3. **Main features of market situation by sector**

	Agriculture	Metal	Energy	Pulp and Paper
Average firm size	Small	Large (except in foundries and in secondary production); in steel industry growing importance of mini-mills	Large, but small plants of growing importance (*e.g.*, in cogeneration)	Large plants (except for specialty products); economies of scale very important
Number of producers	Very large, but decreasing	Small, but growing (in basic metal industry)	Limited number of dominating firms (especially in oil industry)	Small number of dominating firms
Production (capacity) in non-OECD countries	Large, but OECD as a whole is a major net exporter	± 50%; growing; strong competition from CIS since 1990	Very large; OECD is a major net importer	Limited; mainly in China
International trade	Substantial, but regional specialisation limited due to self-sufficiency policies	Important; for steel products: 29% of production (OECD 1996*b*)	Coal and oil: global trade important (> 10% of production); gas: limited (regional); electricity: negligible	Important for pulp; less so for paper
Tariffs and other trade barriers	High; reductions agreed in GATT Uruguay Round	Low for raw materials; higher for finished products	Tariffs for most energy products zero-rated	Low for pulp; higher (up to 10%) for paper (products)
Product differentiation and scope for quality-based competition	Low for bulk products; higher for niche markets	Low for intermediate products; higher for finished products	Limited; exists to some extent in the delivery of "energy services"	Low for pulp; high for paper
Overall outlook for world trade	Likely to increase	Mixed picture; strong growth for aluminium likely	Growth likely, especially for gas	Unclear

of capital, labour, energy and water, thus providing an indication of the sensitivity of changes in the cost of each of these production factors and inputs for each sector.

Table 3 summarizes a number of features which are typical for the four industries on the world market. It shows that all four sectors are exposed to competition on the world market and will continue to be so in the future, in many cases increasingly so. Although large companies are dominating the metal and pulp and paper industries, there seems to be little chance for them to use market power to influence prices. The scope for product differentiation is limited for the basic products, but may be much larger for producers specialising in final products.

4. IMPACT OF SUBSIDY REMOVAL ON COMPETITIVENESS

There are several ways in which one can try to assess the impact of subsidy removal on the international competitiveness of the affected sector. One of them is an analysis of the statistical relationship between subsidies and the export performance of the recipient, on a time series or a cross-sectional basis. Some rough exercises are presented below, which should be considered as no more than that: given the number of compounding factors that are probably involved, firm conclusions on causal relationships cannot be drawn.

Looking at ***agriculture,*** the strongest PSE reductions (in relative terms) in the past decade have taken place in New Zealand, the United States and Canada.[13] The reduction of support in these countries was accompanied by a decrease in the share of agricultural products in total exports. However, while this decrease exceeded the OECD average in the cases of New Zealand and the USA, it was lower in the case of Canada. Relative increases in imports of agricultural products were only observed in New Zealand. The importance of agriculture in the total economy decreased in the three countries at a slower pace than in the EU, where the level of support was not reduced (see Table 4). According to Roodman (1996), the agricultural sector in New Zealand has become much more efficient and New Zealand is now one of the few industrial countries where the number of farmers is currently rising. To what extent subsidy reductions have had an influence on these developments is hard to tell, but they have certainly not eliminated the affected sectors from the world market.

For the ***metal industry,*** no official estimates of subsidies, such as the PSEs or CSEs (Consumer Subsidy Equivalents), are available. An indication of the impact of government support reduction can, however, be obtained by using figures reported by the European Commission on state support. Among the EU members, Spain and Italy provide the highest amounts of support to their steel industries. While Spain has reduced its subsidies drastically over the past decade, state support has been growing in Italy. Over the same period, Spain faced stagnant steel exports, while

Table 4. **Producer Subsidy Equivalent (PSE) and agricultural performance in the OECD and selected Member countries**

	Canada		New Zealand		USA		EU		OECD average	
	1986-88	1992-94	1986-88	1992-94	1986-88	1992-94	1986-88	1992-94	1986-88	1992-94
% of agriculture in GDP	1.5	1.4	5.8	5.3	1.7	1.5	2.6	1.9	2.2	1.8
% of agricultural exports in total exports	7.9	7.8	60.3	50.7	13.0	10.9	10.6	10.7	9.8	9.3
% of agricultural imports in total imports	6.0	6.0	7.2	7.7	5.8	4.8	12.4	11.2	10.4	9.4
PSE (in % of agricultural production value)*	42	26	18	3	30	18	48	49	45	41

* PSE estimates in the column ‘‘1992-94’’ refer to the 1993-95 average instead.
Source: OECD (1997*b*).

Italian exports grew well above the EU-12 average. At the same time, Spanish steel imports grew considerably faster than those of Italy and the EU-12 (see Table 5). However, one should be careful in assuming a causal relationship. As stated in Section 2.2, most of the state support to the steel industry has been decoupled from production, and other factors (*e.g.*, production costs; exchange rates) may have played a major role.

Table 5. **State support, production and international trade in the steel industry, 1986-1994**

Yearly averages

	Spain		Italy		EU-12	
	1986-88	1992-94	1986-88	1992-94	1986-88	1992-94
State support (mln ECU)	891	118	357	645	1 368	970
Crude steel production (1 000 tonnes)	11 865	12 892	23 168	25 577	130 064	134 313
Steel exports (1 000 tonnes)	4 812	4 725	7 075	9 388	67 354	72 286
Steel imports (1 000 tonnes)	2 434	3 584	7 943	9 822	48 226	60 113

Source: Europese Commissie, Overzicht van de Commissie inzake de steunmaatregelen van de Lid-Staten voor de nijverheid en bepaalde andere sectoren in de Europese Unie several years; OECD, *The Iron and Steel Industry*, several years.

In the same way, one can illustrate the impact of subsidy reduction to the ***energy industry*** by looking at the example of coal subsidies in Germany and the UK. These coal subsidies are primarily aimed at protecting domestic production for the domestic market. Table 6 shows that while subsidies in Germany remained fairly stable over the period 1986-1994, the UK reduced state support to its coal production considerably. Coal production in the UK decreased over this same period, whereas it increased in Germany.[14] The UK's decline in production was not compensated for by its increase in imports. This can be explained by the fact that the reduction of subsidies in the UK was accompanied by a liberalisation of its energy markets, leading to a shift to natural gas powered energy at the expense of coal. In other words, the reduction of support to domestic coal producers did not result in a substitution by imports of the same product, but rather in a substitution by a different product (mainly produced by domestic sources).

Similar comparisons for the ***pulp and paper industry*** cannot be made, as data is seriously lacking on subsidies to this industry.

Table 6. **State support, production and international trade in the coal industry, 1986-1994**

Yearly averages

	United Kingdom		Germany	
	1989-91	1992-94	1989-91	1992-94
State support (PSE in mln ECU)	3 595	1 083	5 694	5 610
Coal production (mln tonnes)	80	56	119	127
Coal exports (mln tonnes)	2	1	9	3
Coal imports (mln tonnes)	15	17	13	17

Source: Calculated after IEA, *Energy Policies of IEA Countries* and *Coal Information,* several years. Exchange rates used: 1 ECU = 0.75 GBP = 2.00 DEM.

The general impression from this (limited) sample of empirical data is that reductions in state support do generally lead to a loss of market shares on the domestic market (substitution) as well as on the world market. However, a more detailed analysis would be needed to come to firm conclusions about the role played by (the reduction of) subsidies *vis-à-vis* other factors.

From the limited data set used, one cannot distill any clear evidence of a relationship between the main point of application of the support given to a particular sector and the impact of a reduction in that support on international competitiveness. In theory, if marginal costs increase more than proportionally with production levels, the amount of subsidy needed to increase production to a certain level will be higher using output subsidies than using input subsidies.[15] Therefore, for a given world market price, one might expect less impact in terms of production decreases from a reduction in output subsidies than from the same amount of reduction in input subsidies. For the sectors addressed in this paper, this would mean that agriculture and coal production would be relatively invulnerable to subsidy reduction.

The impact on production levels of subsidies to value adding factors is usually smaller than of those to outputs and inputs. A tax credit for investments, for example, reduces fixed costs but does not influence marginal costs. However, one should keep in mind that such subsidies still effectively reduce total costs, enabling some firms to stay in business which would otherwise operate at a loss in the absence of the subsidy. The same is true for income subsidies to, for example, farmers. In other words, the removal of even those subsidies which do not directly affect marginal costs or marginal revenues may still lead to a reduction in production levels and the competitiveness of the industry.

Support removal and the ensuing loss of competitiveness in Country A may lead to a relocation of formerly subsidised industries to Country B, if the costs of carrying out the polluting activity there become lower as a result. To some extent, this relocation can be desirable, for example if the environmental damage caused by the activity in Country B is smaller. However, the relocation may also simply imply a shift in environmental harm from A to B, for example if Country B applies the same kind of support to the polluting industry and continues to do so after A has reduced its support. In this respect, the issue of unilateral support removal is simply the mirror image of the unilateral introduction of pollution taxes or environmental regulations.

Empirical evidence on the actual relocation of "dirty" industries due to lower environmental costs (or higher "anti-environmental" subsidies) abroad is scant (see for example Low and Yeats, 1992, and Leonard, 1988). Apparently, the cost advantages that result from the absence of environmental standards (or the presence of the subsidies) are small compared to other factors influencing investment behaviour, such as the availability of skilled labour, infrastructure, political stability and proximity to markets. It is also possible that firms are not inclined to relocate their production if they expect that the unilateral action by Country A is likely to be followed by Country B after some delay. Probably, relocation of production is used more often as a threat in discussions on environmental policy tightening than it is put into practice.

The likelihood of industry relocation thus seems to be small in general, but may still show differences depending on certain features of the industry. In the short term, multinational industries which have excess production capacity can easily shift production from one country to another. Low capital intensity and low transport costs are also factors which may ease swift changes in production location in response to changes in factor costs. Capital intensive industries, such as the energy, metal, and pulp and paper industries, will only consider a structural, long term relocation of production when replacing or expanding production capacity. Such major investment decisions will be influenced by several other factors, as mentioned in the preceding paragraph, many of which are likely to be more important than the presence or absence of subsidies.

5. STRATEGIES FOR SUBSIDY REDUCTION

When considering alternative policies for a reduction or elimination of environmentally harmful subsidies, a government should first check to what extent the subsidy is really essential for international competitiveness under the prevailing world market conditions. Some key parameters which may provide indications for the (in-) dispensability of the subsidy have been identified in this paper: the importance of the subsidy (in terms of share in production value), the point of application, the extent to which higher production costs can be compensated by product differentiation and higher quality, etc.

When it is concluded that the subsidy is indeed essential, one needs to determine whether the currently protected industries would have a chance of surviving on a competitive, subsidy-free world market. In the highly developed OECD countries, the chances for survival are probably brighter for industries providing specialised products to "niche" markets, where competition based on quality and product differentiation rather than on price competition is possible. If the industry indeed seems to have a chance for continuing without the subsidies, the potential for an internationally coordinated subsidy reduction should be assessed. If this possibility looks promising, it may be sensible to maintain the national subsidies for the time being, until such time as a multilateral reduction is agreed, because removing them unilaterally beforehand may damage an industry which could become viable again once the other countries have removed their support.

However, if a world wide subsidy reduction is unlikely, or if the domestic industry would not be competitive in a liberalised world market, there is no reason to refrain from unilateral subsidy reduction measures. Assuming constant world market prices and the absence of domestic market distortions, such measures will always lead to a net increase in domestic welfare, even though the previously-protected industry may suffer. Cuts in government spending on socially undesirable subsidies will improve overall welfare, although the beneficiaries are often much harder to identify than the losers. The benefits can be reaped in various ways: for instance by replacing the subsidy by other ones which have a better social benefit/cost ratio; by reducing taxes, which may improve overall competitiveness; or by reducing the government deficit, which may lead to lower interest rates. The reduction in environmental damage due to the removal of the subsidy should also be taken into account when considering the net benefits of support removal. In cases where the subsidy takes the form of market price protection, its abolition may lead to lower prices, thus improving the competitiveness of downstream industries using these products.[16]

One has to acknowledge the fact that political realities may force politicians to favour the interests of the protected industries over general social welfare. Countries whose protected industries would still be competitive under a subsidy-free world market regime may have an interest in an international agreement on subsidy reduction, but not in unilateral actions. This looks like a Prisoners' Dilemma, but in most cases it is a "Pseudo Prisoners' Dilemma" because, in general, there will also be countries which face a loss of competitiveness for their sheltered industries, even under an internationally coordinated scenario.[17] Besides trying to convince such countries that their overall welfare will increase (despite the loss of these industries), the "winners" might need other means to persuade the "losers" to cooperate. Examples of such measures have been mentioned in Section 2 and include "issue linking", side payments and/or sanctions.

In certain cases, the prospective winners could also assume international leadership, entering into an agreement with a limited number of partners and hoping that others will follow suit. Finally, the would-be losers could be lured into cooperation by allowing them to maintain some kind of (less distortionary) support for their endangered industries.

Replacing existing subsidies by less distortionary ones is, of course, always recommendable. The following suggestions for reforming subsidies can be used to decrease the distortionary and environmental effects of support policies:

– E*nvironmentally more compatible subsidies*. Environmentally harmful types of government support could be replaced by environmentally more benign ones, such as tax incentives for energy saving or pollution reduction equipment. However, as has already been indicated, even such "good" subsidies reduce the total costs of a given industry, which may lead to a production level which is too high from a social welfare point of view. Moreover, subsidies linked to, for example, "end-of-pipe" equipment provide a disincentive for alternatives which are intrinsically cleaner.

– O*ther ways of providing support*. Trade rules as agreed upon in the framework of the GATT/WTO do not generally allow for protection of a domestic industry (*e.g.*, because of lower environmental standards in competing countries). Nevertheless, there are ways in which a government can stimulate its industry to prepare for a future international market in which cleaner products and more sustainable production methods will play an important role. Environmental policies (regulations, economic incentives and voluntary agreements) can play a key role here. For example, strict regulations on recycling (which can be justified on the basis of market myopia and the lack of internalised external costs) will stimulate the supply of secondary materials and improve the relative position of the recycling industry. Such industries are usually more oriented to the local or regional market than the producers of primary materials. Similarly, the government itself can decide to spend its money on goods and services with a relatively low environmental impact (*e.g.*, products with internationally acknowledged eco-labels). Obviously, such policies should be carefully designed so as not to come into conflict with international trade rules (they should, for instance, acknowledge national sovereignty on environmental policy making, in particular with regard to non-transboundary issues), but they may still have the intended (side) effect of fostering particular domestic industries.

– R*eplace input and output subsidies by other kinds of support*. Subsidies on inputs and outputs have a direct impact on marginal costs and marginal revenues respectively, and thus on the level of production. Support which is not conditional on input or output levels, such as subsidies to labour, capital or research and development, does not have this direct impact, although it may lead to higher production levels due to its impact on long term average costs. In order to offset the environmental impact from higher production levels which are, *ceteris paribus*, inherent to any kind of subsidy, it seems preferable to subsidise the innovation and diffusion of cleaner technologies and production methods (see also Verbruggen, 1990).

6. CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

The present paper has attempted to highlight the main issues related to the impact of removing environmentally harmful subsidies on international competitiveness. It was concluded that support removal is often perceived as a "Prisoners' Dilemma", in which all players prefer to behave non-cooperatively, despite the fact that a cooperative solution would maximise overall welfare. However, reducing distortionary and harmful subsidies unilaterally is in many cases preferable, even if other countries do not follow suit. On the other hand, the industry which loses its protection will always suffer to some extent, even in the case of an internationally coordinated subsidy removal.

Data on actual support is scarce. Indicators have mainly been developed for agricultural and coal production. An empirical analysis of the impact of subsidy removal on competitiveness is therefore hard to perform and the available evidence is inconclusive. From a theoretical point of view, some conclusions can nevertheless be drawn:

– Subsidies on outputs are less effective than those on inputs, and thus removing the former would have a relatively small impact on production levels.

– The impact on production levels of subsidies to value adding factors is usually smaller than of those to outputs and inputs.

– Relocation of capital intensive industries, such as the energy, metal, and pulp and paper industries, will be influenced by several factors, many of which are likely to be more important than the presence or absence of subsidies.

Future research on environmentally harmful subsidies, and on the mitigation of the adverse competitive effects arising from their reduction or removal, might include the following:

– D*eveloping a systematic approach to surveying input subsidies*. Earlier studies have often focused on output subsidies. From an environmental point of view, subsidies based on the use of inputs, such as (raw) materials, water, energy and space, may be even more environmentally damaging. Many kinds of support in this area have an "off-budget" or disguised character. Developing an internationally standardised method for measuring such subsidies would help to reveal the existing distortions and to design coordinated policies to abolish them.

– D*rafting general guidelines for environmental support measures*. As indicated in this paper, subsidies with environmental purposes may be preferable to environmentally harmful kinds of support, but they are not necessarily "good" subsidies. They may still conflict with the Polluter Pays Principle, and imply a production level in the receiving industry which exceeds the optimum from a social welfare point of view. Obviously, the assessment of such subsidies will depend on the reference situation. Support for environmental investments may be justifiable if they are related to levels of pollution abatement which exceed "reasonable" levels (as determined by, for example, the BATNEEC or ALARA principle). This basic idea could be further elaborated. Likewise, the extent to which preferential treatment of "cleaner" industries and products by the government (for example, through its procurement policies) can be pursued without coming into conflict with international trade rules could be further investigated.

Annex

The Impact of Input and Output Subsidies on Production Levels

Given increasing marginal costs, a certain amount of input subsidy will lead to a higher increase in production than the same amount of output subsidy, or: to achieve a given increase in production, the amount of input subsidy that would be required is lower than the amount of output subsidy that would be needed. This can be shown mathematically using the following example.

Let us assume a simple production function:

$$q = x^{\alpha} \qquad (1)$$

in which q is the amount of output, x is the amount of input, and $0 < \alpha < 1$. The total production costs TC are given by:

$$\text{TC} = p_x \bullet q^{\frac{1}{\alpha}} \qquad (2)$$

where p_x is the price of the input. Marginal costs MC are given by:

$$\text{MC} = \frac{1}{\alpha}(p_x \bullet q)^{\frac{1}{\alpha}-1} \qquad (3)$$

Assuming a constant output price (= marginal revenue, MR) p_q, equalizing marginal costs and revenues (MC = MR) gives the optimum production level:

$$q = \left(\frac{\alpha p_q}{p_x}\right)^{\frac{\alpha}{1-\alpha}} \qquad (4)$$

An output subsidy s_q per unit of output changes the optimum production level into:

$$q = \left(\alpha\frac{p_q + s_q}{p_x}\right)^{\frac{\alpha}{1-\alpha}} \qquad (5)$$

The total amount of output subsidy S_q is:

$$S_q = q \bullet s_q = \left(\alpha\frac{p_q + s_q}{p_x}\right)^{\frac{\alpha}{1-\alpha}} \bullet s_q \qquad (6)$$

Likewise, an input subsidy s_x per unit of input yields an optimum output level of:

$$q = \left(\frac{\alpha p_q}{p_x - s_x}\right)^{\frac{\alpha}{1-\alpha}} \tag{7}$$

Given a certain value for s_q, we can combine equations (5) and (7) to calculate the "equivalent" rate of s_x (*i.e.*, the rate of input subsidy which leads to the same production level as the output subsidy):

$$s_x = \frac{p_x \bullet s_q}{p_q + s_q} \tag{8}$$

The total amount of input subsidy then becomes:

$$S_x = x \bullet s_x = q^{\frac{1}{\alpha}} \bullet \frac{p_q \bullet s_q}{p_q + s_q} = \left\{\left(\alpha \frac{p_q + s_q}{p_x}\right)^{\frac{\alpha}{1-\alpha}}\right\}^{\frac{1}{\alpha}} \bullet \frac{p_x \bullet s_q}{p_q + s_q} = \alpha \bullet \left(\alpha \frac{p_q + s_q}{p_x}\right)^{\frac{\alpha}{1-\alpha}} \bullet s_q \tag{9}$$

Combining equations (6) and (9) gives:

$$S_x = \alpha \bullet S_q \tag{10}$$

As $\alpha < 1$, the input subsidy required to obtain a certain amount of output increase is smaller than the output subsidy needed to bring about the same increase.

Notes

1. Roodman (1996).
2. De Moor and Calamai (1997).
3. Runge (1996) states that bad subsidies tend to drive out good ones ("Gresham's Law of Subsidies").
4. We assume here that the subsidy is a market distortion and does not play a role in correcting market imperfections. In the latter case, removing the subsidy would of course imply a welfare loss.
5. A (long term) welfare maximizing government may, in this case, nevertheless decide to maintain the subsidy in order to have a trump card in international negotiations on subsidy reduction.
6. Obviously, the reverse situation (a producer reaping the benefits of a consumer subsidy in a sellers' market) also occurs. Wolfson (1990) gives some examples.
7. Although subsidy removal may cause unemployment among the workers in the previously subsidised industries, it will create new employment in other industries due to tax reductions, increases in demand, etcetera. The net effect on employment can still be negative, especially if the formerly subsidised industry is a labour-intensive one. Positive employment impacts could in such cases be achieved by recycling the funds through, for example, job re-training schemes.
8. Excluding Eastern Europe and the former USSR.
9. Calculated after European Commission (1997) and Europese Commissie (1997).
10. Subsidies for renewables are examples of the kind of subsidies, mentioned in Section 1, which have an environmental objective or motivation, but which are not necessarily environmentally benign: they do change relative prices to the advantage of renewable energy, but at the same time they have a decreasing impact on average energy production costs, thus offsetting at least part of the environmental gains.
11. Gross inland energy consumption in the EU was 1 338 Mtoe in 1994; prices of coal, fuel oil and gas for industrial users were in the range between 100 and 120 ECU per toe in that year (European Commission 1996).
12. Gross inland consumption amounted to 2 038 Mtoe in 1994 (European Commission 1996); same prices used as in endnote 11.
13. Ignoring for the moment the special cases of the new OECD members in Central and Eastern Europe.
14. One should be aware of the fact that the German figure is influenced by the unification in 1991. If only the old Länder are considered, a slight decrease in Germany's coal production would probably be observed.

15. This is mathematically illustrated in the Annex.
16. In such cases, removing a subsidy will not necessarily result in environmental improvement. For example, if protection of a domestic coal market is abolished, coal users may turn to (cheaper) imported coal. Consequently, complementary environmental policies will still be needed.
17. Moreover, there may be countries which do not apply subsidies themselves, but will be damaged by subsidy reduction taking place in other countries. Energy exporting countries, for example, will suffer from energy subsidy reductions by energy importing countries. Furthermore, if energy subsidy reduction leads to a "dematerialization" of the economy, countries specializing in the export of raw materials may suffer as well. Although these countries are not direct players in the subsidy reduction game, they may have an influence on the outcome of the negotiations through their lobbies.

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