Some economic aspects of climate change. Instruments and statistics

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Abstract

The Stern report (Stern, 2008) addresses the climate change and economic consequences of emission of greenhouse gases, the cost of mitigation up to a certain level, and the cost of adaptation. In this note, we focus on the mitigation aspects and instruments in particular. We do not address the adaptation aspects. The Stern report argues for a range of instruments, i.e. a combination of economic instruments, technology instruments, regulatory instruments etc. We show that principally all instruments create shadow prices in the market. Actually all instruments may be perceived to be just a combination of the two simple tax and subsidy instruments, although the combination factor is endogenous. We then produce a comprehensive number of consistent statistical tables that allows us to perform analyses both of driving forces behind emissions, and the impact of the instruments on emissions. We exemplify some interesting aspects by combining actual figures for Norway from a set of such consistent tables.

1. Introduction

The stern report (Stern, 2008) addresses the climate change and economic consequences of emission of greenhouse gases, the cost of mitigation up to a certain level, and the cost of adaptation. In this note, we will discuss the need for statistics related to mitigation and instruments. We do not go into detail for the other aspects, only that this implies some sort of cost benefit analysis of the climate change challenge.

Some key point from the Stern report is: i) All countries will be affected by climate change, but the poorest countries will suffer earliest and most, ii) Climate change is the greatest and widest-ranging market failure ever seen, iii) Three elements of policy are required for an effective response: carbon pricing, technology policy and energy efficiency, iv) Carbon pricing, through taxation, emissions trading or regulation, will show people the full social costs of their actions. The aim should be a global carbon price across countries and sectors, v) Technology policy should drive the large-scale development and use of a range of low-carbon and high-efficiency products, vi) International product standards could be introduced, vii) The benefits of strong, early action considerably outweigh the costs, viii) The cost of reducing emissions could be limited to around 1% of global GDP if measures introduced are cost efficient.

Cost efficiency, taxes, carbon markets, technology policy (Subsidies and R&D), product standards (regulation), strong early action, and the cost of action – these are the main formulas, i.e. we should focus on economic instruments and cost efficiency in the mitigation process of climate change. Some would argue that we can not focus only on economic instruments – and that the Stern report also focuses on technology policy, standards, best practice etc. Our view is that these are also economic instruments – all standards, regulations, R&D support will actually by market effects work just as ordinary economic instruments like taxes and subsidies. A range of new instruments are already implemented in several countries, for instance green and white certificates. Again these are combinations of taxes and subsidies although the combination factor is endogenous and depends upon elasticities on the supply and demand side of the markets. Implementation of such instruments creates a need for monitoring and production of statistics.

In section 2 we discuss how some of the instruments introduced to try to combat climate change actually work. Although the instruments appear different, there is a striking resemblance with respect to effects in the market. The effects reduce to the effect of a combination of only two instruments. An open question is then – why introduce many elements if only two is enough? Producing statistics to trace the effects of several instruments is more complex than producing for two instruments (in addition to the administrative costs).

In section 3 we up a consistent set of statistical tables that enables us to trace both the driving forces for environmental consequences, the instruments introduced to combat the changes and the net effect of these two. These data tables should form a perfect information base for those who are interested in background statistics and for analyses of the impacts of policy measures.

In section 4 we illustrate the usefulness of a combination of three of the tables that we argue for in chapter 3. The empirical example is from Norway.

2. Economic instruments[1]

Over the last few decades, several instruments have evolved to deal with similar energy and environmental challenges. For instance, the economic literature prescribes separate tax or cap-and-trade systems to internalize negative environmental externalities and subsidies to internalize positive externalities such as R&D. However, policy is not straightforward because of the influence on cost and competition and concerns for regional employment, economic activity within certain industries, and any distributional effects. Tax discrimination, subsidies and regulations then undermine the efficiency of energy instruments. To balance any environmental concerns, other instruments, including green and white certificates, have been created. While they seem innovative economic analysis will reveal that these work as simple combinations of taxes and subsidies.

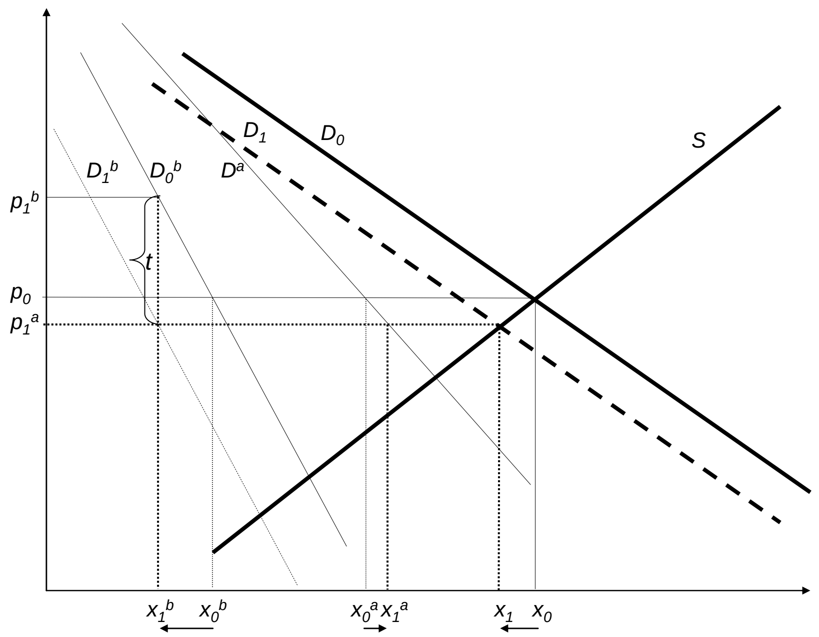
Several articles discuss the effect of one by one instrument and in some instances the literature also addresses the combination of two instruments. Both types of studies show that analytical results may be derived, but the conclusions with respect to sign for prices and volumes changes are ambiguous. This demands empirical analyses which again strengthen the need for relevant statistics. This becomes even more important when introducing three and more instruments. Then analytical derivation of results becomes impossible and empirical analysis is the only way out.

Below we give some brief understanding of the complexity of even partial instruments, one by one, to highlight a simple point – all instruments reduce to a combination of a tax and a subsidy – the composition may differ, and in most instances the composition is endogenous.

2.1. Discriminatory taxation

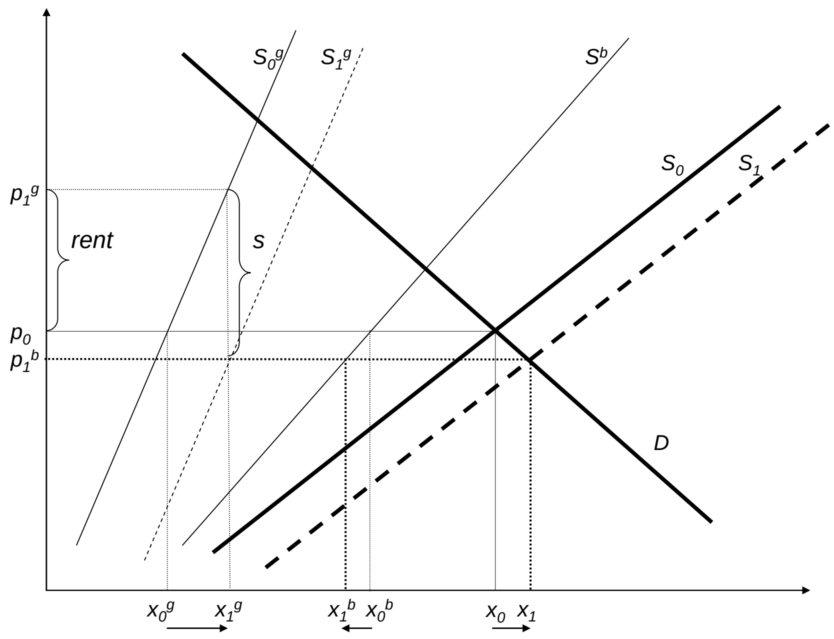
Figure 1 depicts an energy market facing an upward sloping supply curve (increasing marginal cost) and two downward sloping demand curves (decreasing willingness to pay) for two consumers. They add up to the market demand. For the purpose of practical policy, consumer D^b faces a tax while consumer D^a is exempted. Such discrimination usually favours the most price elastic consumer, i.e., the industry is exempt or faces reduced taxes (whether it is a carbon or an energy tax), while households face the highest tax rates. A trained eye easily sees that the exempted consumer also captures a market benefit at the equilibrium price drops, i.e. the discriminatory tax combines a tax and an implicit "subsidy". If we instead assumed two producers and one consumer, the reasoning would be the same. The taxed producer reduces his production, equilibrium prices increase, and the non taxed producer harvests a market "subsidy".

[1] We only briefly discuss the illustrations in this chapter. For the interesting reader we refer to Bye and Bruvoll (2008) who thoroughly discuss both the principles and the illustrations in detail.



2.2. Discriminatory subsidies

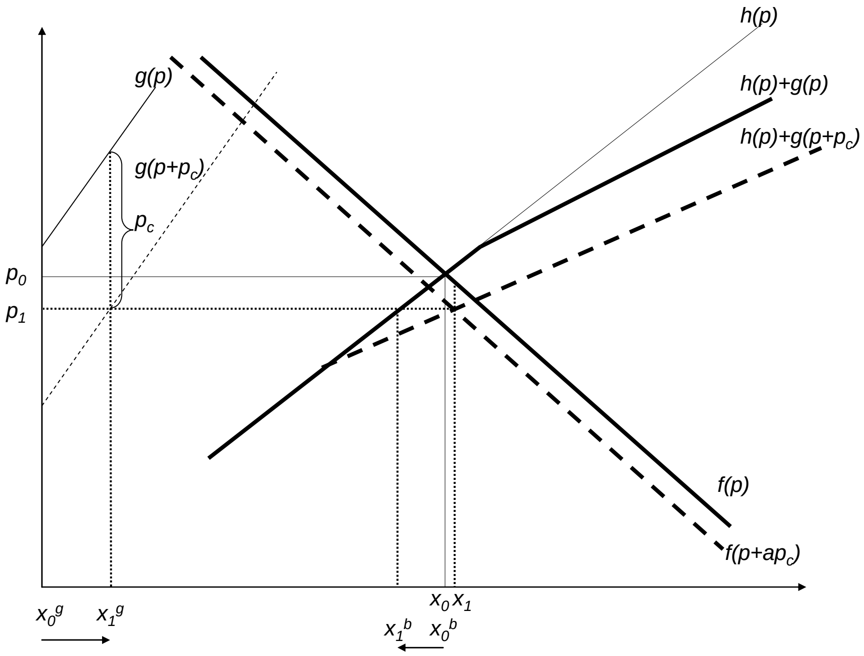
Let us assume two producers and one consumer. One producer applies carbon technology the other one is renewable. The economic advice would be to internalize the emission costs produced in the carbon technology by a tax or a restriction (shadow price – i.e. carbon market). However, policy makers seem to favour "positive" to "negative" instruments, so instead the renewable technology is subsidized. The subsidy shifts supply outwards, the market price drops, and the producer that do not receive a subsidy is implicitly taxed.



2.3. Green Certificates – who is subsidised and who is taxed?

A green certificate is proof of an environmentally favourable origin of an amount of energy produced. This instrument particularly focuses on the supply side of the energy market. The government issues a green certificate to the producer for each unit of secondary energy produced by a green energy carrier. Consumers are required to purchase a number of certificates proportional to the total amount of their energy consumption. This creates a market (paper market) for the green certificates. The producers of green energy harvest a certificate price in the certificate market additional to the energy price in the energy market. This increases the profitability of producing energy from green technologies. An advantage over a simple lump sum subsidy is the incentive for cost efficient investment for capacity expansion that this instrument creates. The system is then comparable to an auction-based subsidy system.

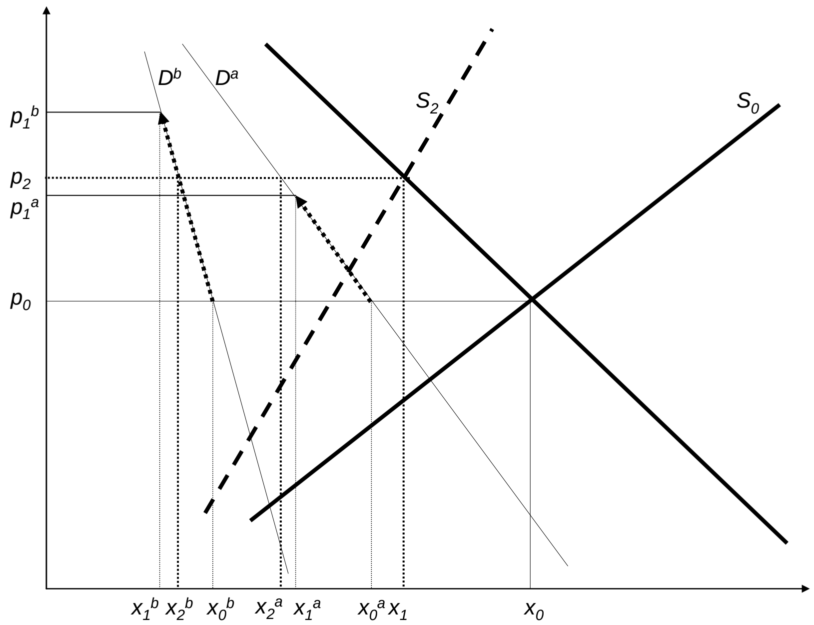
Through this paper market the producer that applies renewable (green) technologies obtain a subsidy i.e. his supply curve shifts outwards. The consumer that has to pay for the paper faces initially a “tax”. The theoretical literature in this field shows that the consumer effect is ambiguous. Empirical analyses suggest that the consumer actually harvest a subsidy while the existing “dirty” producers pay for all.



2.4. White Certificates – who is subsidised and who is taxed?

While green certificates deal with the supply side, white certificates primarily concern energy savings on the demand side. A white certificate system may impose a restriction (a “tax”) on total allowable energy consumption for separate consumer groups (the principals). In practice, the restrictions are imposed on distribution companies (the agent) or the energy suppliers (e.g., white certificate systems in Italy, France, and the United Kingdom). These agents invest in energy efficiency measures on behalf of their consumers in a cost efficient way, i.e. they trade savings potentials among consumers, and consumers eventually pay through additions to energy tariffs.

Hence, the white certificate system is principally a combined system of a tax on the consumption and production of energy and a subsidy for suppliers of energy-saving appliances. Again, this instrument combines the two well-known tax and subsidy instruments.

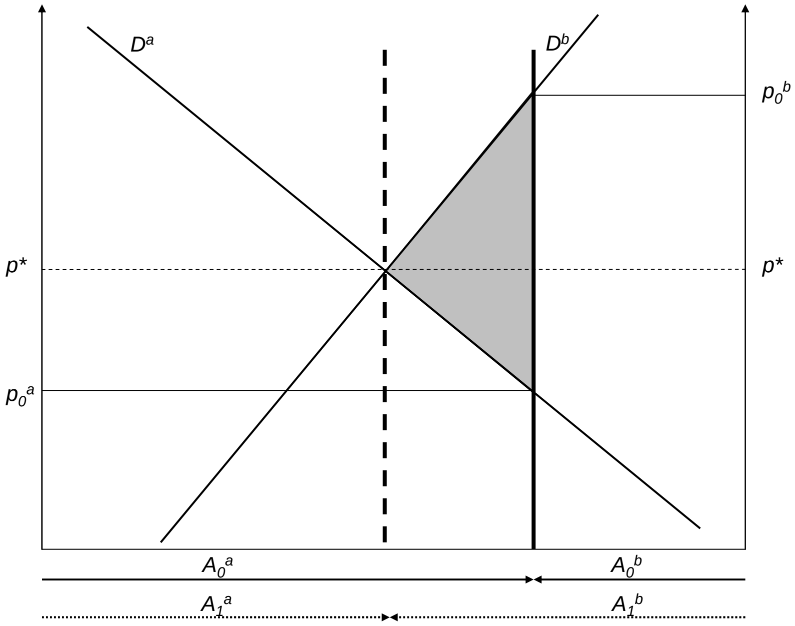


2.5. Brown Certificates (carbon markets) – who is subsidised and who is taxed?

We can regulate externalities with either price (as with the exogenously set taxes described above) or volume. Optimal taxes should equal the (estimated) external marginal costs. The level of emissions will then be endogenously determined. However, it is typically easier to relate regulation to society's perception of the optimal emission level. An alternative to carbon taxes is then a cap-and-trade system, so-called *brown* certificates. In principle, if all emitting sources were included, a cap-and-trade system could directly regulate total emissions as committed to in international agreements and the permit price would equal the necessary tax to reduce emissions. According to the literature, this is in many senses equally efficient to a tax system. This is then the efficiency concept of cap and trade.

This system also comprises an income distribution aspect, i.e. the distribution of permits among producers/consumers for free. The distribution in itself does not conflict the efficiency measure, however, it implies a subsidy element.

The initial distribution of permits among producers/consumers determines the distribution of the total value of the permits that occurs in a market with free trade. Both the assignments of free allowances (i.e., income transfers resulting from competitive concerns) as well as the auction of permits based on fundamental polluter-pays principles produce the efficient final allocation of permits, *as long as* there is no restriction with respect to trade. In practice, this policy proves hard to achieve. Given the preceding allocation of value through unregulated emissions, optimal trade and permit prices cause cost increases, reduced activity, and the closing down of firms, all of which appear as politically controversial. Free allowances are then not only used as an income transfer alone, rather *as a subsidy* for existing activities to keep them running.



2.6. Regulation and standards – the shadow price and market effect

In a perfectly competitive market, consumers invest in the most cost efficient appliances. This results in comprehensive combinations of technology choices. In some instances, politicians introduce standards for energy consuming appliances to stimulate and increase the relative competitiveness of green to polluting technologies. The introduction of standards, for instance, best available technology (BAT), imposes restrictions on consumption/production technology choices. Since the willingness-to-pay, i.e., costs related to different technology choices, varies, standards imply varying shadow prices. In line with the initial regulation exemplified in relation to white and green certificates in Figures 6 and 7, this implies differentiated taxes and subsidies among consumers/producers.

2.7. R&D

The economic reasoning for supporting R&D is to capture the effect of a positive externality, when increased knowledge spread and other actors gain.

R&D support is principally a "discriminatory" subsidy, it is meant to foster a development in a predetermined direction, although the details about this direction are uncertain. If we support development in one direction the market outcome works as a tax on alternatives. Hence R&D is directly comparable to the subsidy effects described in chapter 2.2.

2.8. Other aspects

The exercise of market power in energy markets power keeps volumes low and prices high. This is comparable to some of the tax effects. For instance, the market power of OPEC plays an important environmental role, not only in supplying oil, but also in keeping consumption and emissions down. Taxes on the monopoly producer's product may then, contrary to intuition, play a minor role in combating pollution as the tax may instead compete for the monopoly profit. Taxation may reduce the producer price while the consumer price may change less and, consequently, consumption and emissions may change less. The conclusion is that the effect of a tax is not straightforward in markets where market power is exercised.

3. Economic instruments and statistics – a system of tables?

Above we have shown that climate policies consist of a portfolio of complex instruments. This highlights the need for detailed information about each instrument to be able to do any serious analysis about the combined effect of these instruments. The information must be set up in a systematic way. Below I discuss this in the context of formal table suggestions and also make some suggestions about data sources.

Table 1 is the fundamental table combining the energy and national accounts (or energy balances combined with national accounts). This is the input matrix from the energy account. The connection to the national account is foremost for analytical purposes. However, some of the emission factors are also linked to output variables in the national account.

Table 3.1 A sector commodity table (from input output tables) – the point of departure

<table>
<tr><td>Sector</td><td></td><td>Gasoline</td><td>Fuel oil</td><td>Coke</td><td>Coal</td><td>Wood</td><td>Waste</td><td>Intermediates</td></tr>
<tr><td rowspan="3">Primary industries</td><td>Agriculture</td><td colspan="7" rowspan="16">Amount of emission carrier - physical or economic values (fixed prices)</td></tr>
<tr><td>Fisheries</td></tr>
<tr><td>Forestry</td></tr>
<tr><td rowspan="4">Manufacturing</td><td>Pulp and paper</td></tr>
<tr><td>Machinery</td></tr>
<tr><td>Metals</td></tr>
<tr><td>Other</td></tr>
<tr><td>Construction</td><td></td></tr>
<tr><td>Electricity etc</td><td></td></tr>
<tr><td rowspan="4">Private Services</td><td>Banking</td></tr>
<tr><td>Insurance</td></tr>
<tr><td>Transport</td></tr>
<tr><td>Other</td></tr>
<tr><td>Public services</td><td></td></tr>
<tr><td>Residential</td><td></td></tr>
</table>

To produce the emission table (table 3), we need a matrix of emission factors directly linked to table 1, this forms table 2 A-E, i.e one table for each compound.

Table 2A-E. The corresponding emission coefficient table (one table for each greenhouse gas)

<table>
<tr><td>Sector</td><td></td><td>Gasoline</td><td>Fuel oil</td><td>Coke</td><td>Coal</td><td>Wood</td><td>Waste</td><td>Intermediates</td></tr>
<tr><td rowspan="3">Primary industries</td><td>Agriculture</td><td colspan="7" rowspan="15">Emission coefficient of compound x on the cell activity from table 1</td></tr>
<tr><td>Fisheries</td></tr>
<tr><td>Forestry</td></tr>
<tr><td rowspan="4">Manufacturing</td><td>Pulp and paper</td></tr>
<tr><td>Machinery</td></tr>
<tr><td>Metals</td></tr>
<tr><td>Other</td></tr>
<tr><td>Construction</td><td></td></tr>
<tr><td>Electricity etc</td><td></td></tr>
<tr><td rowspan="4">Private Services</td><td>Banking</td></tr>
<tr><td>Insurance</td></tr>
<tr><td>Transport</td></tr>
<tr><td>Other</td></tr>
<tr><td>Public services</td><td></td></tr>
<tr><td>Residential</td><td></td></tr>
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The product of table 1 and table 2 forms the emission table, table 3, i.e one tabl for each compound. In practice there may be some adjustments to this concept but that is not important in our context now.

Table 3A-E. The corresponding emission table

<table>
<tr><td>Sector</td><td></td><td>Gasoline</td><td>Fuel oil</td><td>Coke</td><td>Coal</td><td>Wood</td><td>Waste</td><td>Intermediates</td></tr>
<tr><td rowspan="3">Primary industries</td><td>Agriculture</td><td colspan="7" rowspan="15">Amount of emissions of compound x – the product of table 1 and 2</td></tr>
<tr><td>Fisheries</td></tr>
<tr><td>Forestry</td></tr>
<tr><td rowspan="4">Manufacturing</td><td>Pulp and paper</td></tr>
<tr><td>Machinery</td></tr>
<tr><td>Metals</td></tr>
<tr><td>Other</td></tr>
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<tr><td>Public services</td><td></td></tr>
<tr><td>Residential</td><td></td></tr>
</table>

The rest of the tables should be linked to these 3 tables. This will make analyses of the effect of instruments much easier and complete than present statistics do. Some of the tables are on a vector basis, i.e. one column for each sector, some on a matrix basis, i.e. several elements for each sector. We do not produce formal tables, but rather discuss the type of table and what content is needed.

Table 4 The corresponding tax table

What is an environmental tax? In the environmental context the tax basis should normally be the volumes of some kinds of proven environmental impact or indicator for impact, for instance emissions of carbon dioxide. In theory and for only one compound this is simple. But in practice and for the general environmental tax concept it may be a complex matter to define environmental taxes and to separate the environmental aspects from other aspects in a tax, cf. Eurostat 2001). In the Eurostat guide all transport taxes are categorized as environmental taxes, while obviously some part of the tax is a Ramsey tax and some part is an infrastructure tax. For a discussion of the categorization of taxes see Bye and Bruvoll (2007)[2]. For greenhouse gas taxes such categorization should be easy?

Taxes on products are normally based on tax rates times the amount/value of the product. The authorities would be the perfect information source for the tax rates – even when they discriminate with respect to source. A separate table for tax rates consistent with table 3 then enables us to calculate the taxes on the basis of tax rates times the volume in table 3A-E. This should harmonize with the total collected taxes measured in public accounts (i.e. a tax account matrix).

A uniform tax rate for greenhouse gas emissions is easy to implement according to table 3. But in practice a discriminatory approach is almost always implemented out of some political reason. This enhances the tax table in several dimensions; in the energy dimension energy uses for processes (P), transport (T) and stationary (S) purposes are treated differently. i.e. the table heading should be expanded by these three categories for each energy product for each sector with different tax rates. Exemption from a tax then shows up as a zero tax.

Sector	Gasoline			Fuel			Coke			Coal			Wood			Waste			Intermediates		
	P	T	S	P	T	S	P	T	S	P	T	S	P	T	S	P	T	S	P	T	S
Agriculture																					
Manufacuturing																					
Services																					
Households																					

A recent paper by Steinbach et al. (2008a) discusses Environmental taxes in the context of the SEEA manual. It seems as if the focus in their paper is to categorize taxes in an income study context (national account) and not the analytical context of environmental efficiency. Our focus is on the data basis for environmental economic analysis, which of course also should be consistent with national accounting, cf. table 1-3.

Table 4 The corresponding subsidy table

What is a subsidy? Generally this is a measure that keeps prices below their market value for consumers and above market value for producers. In practice this may be direct transfers or tax credits (foregone income). In UNEP (2004) direct transfers, public R&D, preferential tax treatments, price controls and loans (with a lower than market interest rate) are included in subsidies. In chapter we have a much broader definition of subsidies. However, this broader definition is only possible to calculate indirectly, taking into account market responses.

Subsidies are normally launched to investment projects in terms of a specific amount or a lump sum, to producing facilities based on a production basis (for instance a feed in tariff – i.e. a unit subsidy) or for facilities that want to save the use of input (energy efficiency projects) on the demand side, either lump sum or per unit. Lump sum subsidies are normally linked to some kind of volume measures, i.e. they may be transformed to a unit measure. In practice this measure is complex and some data transformation processes are needed to make the measures comparable in units. Subsidies are normally directed towards detailed projects, i.e. these data are on matrix form, cfr. table 3.

The bright side of this is that the public sector will normally establish some kind of a register for the budgeting and accounting and the following up of such projects. Then the data collection is reduced to harvesting from public registers, while the transformation process may be demanding.

[2] Cfr that a tax is a compulsory payment to the government where the benefits provided by the tax payer are not directly linked to the payment in opposite to fees or charges where the individual benefits are more linked to the payment. For some reason Eurostat categorize the CO_2 tax as an energy tax?

A recent paper by Steinbach et al. (2008b) discusses Environmental taxes in the context of the SEEA manual.

Table 5A-B. The corresponding greenhouse gas allowances and permit trade

An alternative to tax environmental stress, to internalize the external cost in market operations, is to set an upper target of allowances and allow trading of these allowances, i.e. a shadow price of the restriction shows up in the market. Generally, a shadow price equal to the tax will produce the same cost efficient environmental output.

This subject demand two sets of statistical tables – one for the initial assignment of free allowances in volumes (implies also a value transfer – volume times the market price) and a second for a following up of the economic and volume exchange through the trading of emission permits in the "market" (see below), both specified at the firm level (aggregated to sector level – see table 3). This are aggregates over the columns in table 3, not specific for each column, i.e. they are normally directed towards sectors and not activities within a sector.

The assigned amount of allowances may be collected from public registers, this could be divided into grandfathered, i.e. based on historic emissions, and other free emissions (for instance for new facilities). A supplement could be surrendered emission, if the firm out of some reason used less than what was assigned and was not allowed to sell abundant allowances in the market. The "verified" emissions follow from table 3.

The second part of this table covers the trade of permits – both volumes and values. This comprises domestic trade and international trade. The international trade involves trade on a market and trade through CDM and JI. Principally, it should be possible to gather data from the permit exchange on a firm basis. However since this market is supranational, this is probably not possible. The question is then whether we need gross or net trade.

It may be possible to calculate net trade of permits as assigned amount less the surrendered amount and the verified emissions. All CDM and JI projects must be formally accepted on a firm basis, i.e. such registers exist. From the accounting matrix and the register information of CDM and JI we may deduct the net trade on the exchange on a firm basis.

A discussion of the permit market in the context of the SEEA manual and the SNA is given in Olsen (2008).

Table 7. The corresponding green certificate table – or electricity certificate or ----
A saying is that a dear child has many names, this also yield for green certificates. Some call it electricity certificate. The instrument as such may evolve to other markets as for instance the gasoline market and then may be named a bio fuel market, etc. The name and market does not really matter for the principals. The clue is that somebody has to approve the chosen technology as green and deliver the certificates, i.e. a public register. The market is also unitary, i.e. the value of the certificate forms directly the price. The register contains information about the technology choice, the firm, and the volume. Since there is a common market for these certificates the price may be collected directly from the exchange. When a firm participates in different certificate markets we should collect different prices and prices may look different if we base the aggregation on the energy balance (residential) or the energy account (territorial) framework.

Table 8. The corresponding white certificate table
As for the green certificate table, the white certificate table may be based on a public register of how much each firm/sector is supposed to save. Since it is not reasonable to imagine that all actors actually participate in the trade of energy savings, cf. the principal agent assumption, this eases the data

collection. Each agent (for instance a distribution company for electricity) has to verify the savings and the cost for each principal (consumer), i.e. the exact information wee need in our statistics.

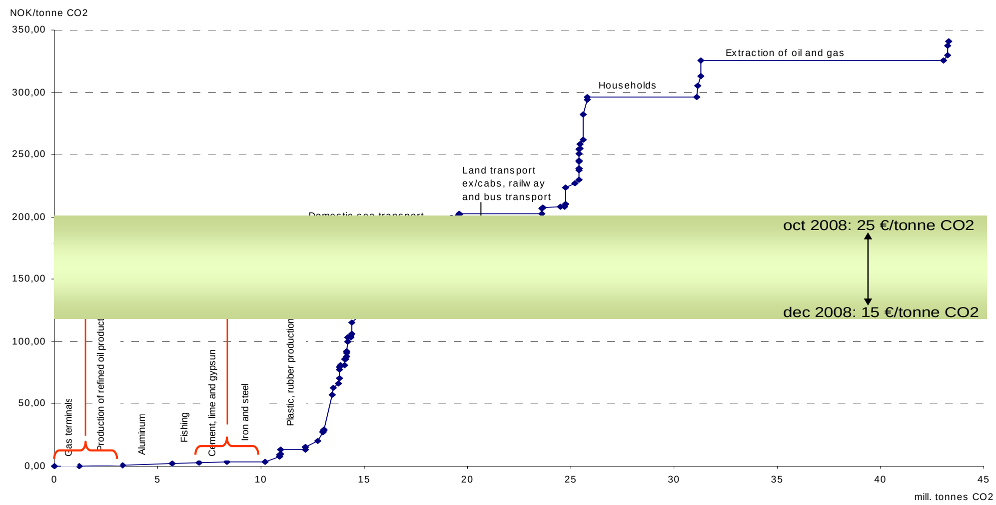
Table 9. The corresponding regulation table
A regulation regime should be easy to cover in the statistics, since the regulations normally are set up by public firms on a firm specific regime. Since the public sector should follow up on their own regulation both the regulated and the verified outcome is registered. The information needed then should be based on these registers.

4. Some empirical illustrations

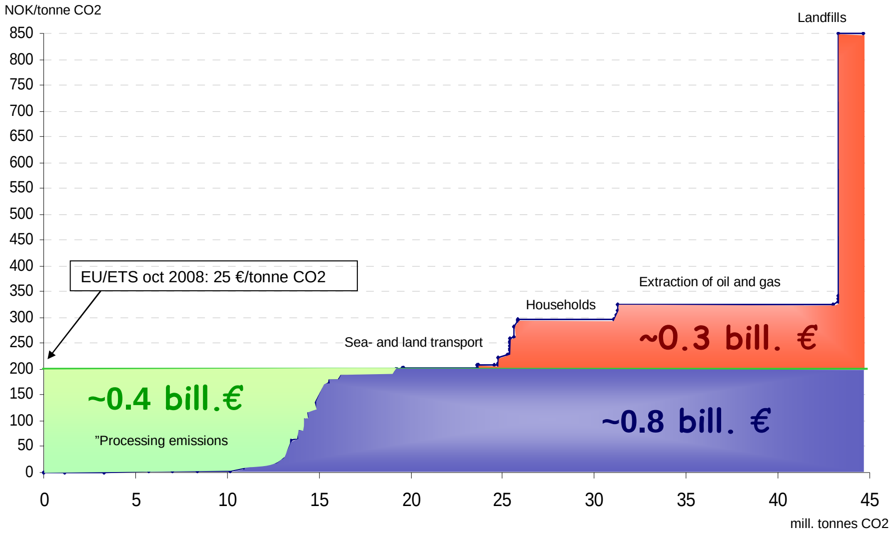
To our knowledge nobody has ever developed a complete set of tables like the ones discussed above, although Eurostat produces comprehensive tax data. However, we should struggle in this direction to be informative about the development of instruments applied to address the climate change problem, and help researchers to get proper information to be able to analyse the effects of all these instruments.

Below we have added an illustration of some of the points made including information from a pilot study of elements in table 3, 4 and 5 for Norway, see Bruvoll and Dalen (2008). On the x-axis we find accumulated emissions of greenhouse gases over commodities and sector on the y-axis we find the actual tax paid. We clearly see that some sectors are exempted, some face a low taxes and some face high taxes. Typically, manufacturing industries are exempted or pay a low tax while households and the petroleum sector pay a high tax. This is a perfect illustration of the burden sharing within Norway. It also illustrates an important cost inefficient approach to the problem, both compared to a domestic approach and compared to an international approach with permit trade (see the green shaded area for the variance of the European permit price (ETS) .

The figure also comprises a start of an emission allowance regime. This is interesting since the earlier exempted or low tax emitters now typically are included in an emission permit trade system while the earlier heavily taxed payers are not. This will obviously move the tax system in a more efficient direction.



From these figures we now may calculate the amount of the burden sharing among emitters in Norway, se figure 2. The figure illustrate that out of the total tax of 1.1 billion Euro in 2006, households, petroleum extraction and landfills pay 0.3 billion Euro to much and process industries pay approximately 0.4 billion Euros to little. Compared to carbon price in the ETS market the average domestic price almost right (0.1 Euro to much) while the distribution of the burden is not cost efficient.



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