Discussion Papers No. 599, December 2009
Statistics Norway, Research Department

Annegrete Bruvoll

On the measurement of environmental taxes

Abstract:
The purpose of environmental taxes is to correct the market when it fails to take environmental damages into account, i.e. to internalize the Pigouvian element. In addition, fiscal taxes are levied on both polluting and clean goods, which may follow the Ramsey principle. In practical policy, environmental and fiscal taxes are conceptually intertwined. This mixture complicates the calculation of the extent and the evaluation of the effects of environmental taxes. Eurostat, OECD and IEA include all taxes related to energy, transport and pollution, and most resource taxes in their international measurement of environmentally related taxes. Consequently, numerous fiscal taxes are added together with the environmental taxes. This article discusses the distinctions between the Pigouvian and the fiscal taxes in light of tax theory. The revenues following the Eurostat et al. statistical basis deviate significantly from the revenues from the environmental taxes defined on the basis of theory. Steps should be taken to harmonize the international statistics of environmental taxes with economic tax theory.

Keywords: Environmental taxes, Fiscal taxes, Pigou taxes, Ramsey taxes

JEL classification: H23, Q65, Q58

Acknowledgement: I am grateful for valuable comments from Torstein Bye, Erling Holmøy and Bodil Larsen to an earlier version of the paper.

Address: Research Department, Statistics Norway, P.O. Box 8131 Dep., 0033 Oslo. E-mail: agb@ssb.no

Discussion Papers comprise research papers intended for international journals or books. A preprint of a Discussion Paper may be longer and more elaborate than a standard journal article, as it may include intermediate calculations and background material etc.

Abstracts with downloadable Discussion Papers
in PDF are available on the Internet:
http://www.ssb.no
http://ideas.repec.org/s/ssb/dispap.html

For printed Discussion Papers contact:

Statistics Norway
Sales- and subscription service
NO-2225 Kongsvinger

Telephone: +47 62 88 55 00
Telefax: +47 62 88 55 95
E-mail: Salg-abonnement@ssb.no

Introduction

Increasing awareness of environmental problems over the past few decades has resulted in a larger focus on environmental taxes as a means to correct negative externalities. To illustrate the extent of environmental tax reforms as part of the general policy focus on environmental protection, Eurostat, OECD and IEA have established routines for the collection of data on the magnitude of environmental taxes in terms of *tax revenues* (Eurostat 2001, OECD 2009). This information is seen as important indicators for the development of environmental protection over time and across countries, and is used in areas such as environmental policy and fiscal policy and reform, as well as for analytical purposes.

The measurement of environmental taxes is not straightforward. All taxes are principally justified in market failures, distributional or revenue concerns, and environmental taxes are clearly defined in economic theory. In practice, however, each political target involves several types of instruments, and each instrument is often designed to achieve several targets (Bye and Bruvoll 2008). Also, the presence of both environmental and fiscal taxes influences the optimal tax structure (Sandmo 1975). When moving from theory to the implemented taxes, the entanglement of instruments complicates the calculation of the environmental elements as share of total taxes on polluting goods. As a consequence of practical problems and political desire to appear environmentally friendly, taxes may be described and incorrectly named as environmental despite low or no environmental externalities. What is called environmental taxes may in practice include fiscal elements, and vice versa.

These definition problems characterize the official international statistics. Due to problems with defining objective and comparable databases, the international statistics developed by Eurostat, OECD and IEA (Eurostat 2001) are not based on a theoretical definition of environmental taxes. Instead, the official statistics cover all *environmentally related* taxes; i.e. taxes related to *energy*, *transport* and *pollution*, as well as taxes levied on *resources*. If we take *environmentally related* as a literal classification, it would in principle extend to every type of tax, as all taxes affect economic activity which in turns affects the use of energy, environment and other externalities.

Hence, to interpret the statistics as environmental taxes is misleading, as it clearly includes other elements such as fiscal taxes and resource rents. Even though the Eurostat et al. framework use the term environmentally *related* taxes in their original definition, their official figures are presented and interpreted as *environmental taxes* (see e.g. European Environment Agency 2005, OECD 2006, Eurostat 2008). This forms the public opinion on the ranking of the environmentally friendly policies across countries on a faulty basis. As scientists seemingly presume that the concept of environmental taxes corresponds to a theoretically consistent definition, the data base is used to analyze a range of problems, e.g. the effect of environmental taxes on economic growth (Morley 2009), cultural differences as an explanation to the acceptance of environmental taxes (Sterner and Köhlin 2003) and the development in environmental taxes over time in and between countries (Ekins 1999). Consequently, scientist may draw misleading conclusions on the causes and effects of environmental policy.

In this article, we discuss the separation of environmental taxes from other taxes in light of tax theory and present a theoretically consistent guideline of how to calculate the environmental tax elements. To study the statistical measurement problem empirically, we compare the *environmental taxes* based on the theoretical definition with the internationally reported *environmentally related taxes* as defined by Eurostat (2001). We find that the international figures include tax bases far beyond the environmental elements, and that the lack of theoretical foundation for the international figures involves several limitation and interpretation problems. Steps should be taken to harmonize the calculation of environmental taxes with economic theory.

Theoretical framework

An environmental tax is a type of Pigouvian taxes (Pigou 1920, Sandmo 1975), which are levied to correct the marginal effects of negative externalities. An optimal environmental tax should be levied directly at the externality, and equals marginal damage cost (*MDC*) of the emission. Environmental taxes serve two purposes. First, the taxes give cost efficient *emission reductions* when the marginal abatement cost is below the tax level. Second, *the polluters pay* the cost of the remaining emissions. This payment corresponds to the *environmental tax revenue,* as is the focus of this article.

The size of the revenue does not carry any information about emission changes resulting from the tax. In some cases, an environmental tax may have virtually no effect on emissions. For instance, given current price levels, the CO_2 tax on petrol has very little effect on transport volumes (cf. e.g. OECD 2006). But the tax is still an environmental tax, and ensures the polluter pays principle.

In the real world, environmental taxes are just part of the overall tax system. The main reason for levying taxes is to raise revenue for publicly provided goods, i.e. *fiscal taxes*. To avoid market distribution leading to deadweight losses, fiscal taxes should be levied where they are least likely to distort economic activity. The standard theory of optimal taxation is based on Ramsey (1927). Under simplifying assumptions, e.g. disregarding externalities, Ramsey showed that the fiscal tax rate on a good should be inversely proportional to the corresponding own price elasticity of demand.

When both fiscal and Pigouvian taxes exist, i.e. for polluting goods, the optimal taxes will not simply be the sum of the *MDC* and the Ramsey tax (Sandmo 1975, 2000). As shown by Sandmo, the optimal tax rates are weighted averages of that computed under the Ramsey inverse elasticity rule and the Pigouvian marginal social damage. Formally, let the weights be a and $(1\text{-}a)$, and T_R the tax rate that maximizes the governmental revenue (i.e. the inverse elasticity). The optimal tax rate to the good then becomes:

[1] $$T = a\, T_R + (1\text{-}a)\, MDC \qquad 0 < a < 1$$

The first element reflects the fiscal element, while the second element reflects the Pigou element. The magnitude of the parameter *a* should reflect the tightness of the government's budget constraint or the marginal cost of public funds (Sandmo 2000). This will vary between taxes and goods. The results of Sandmo are important to the interpretation of the size use of environmental taxes. When decomposing the total revenue from the tax on a polluting good, each *ascribed* part will be equal to or lower than the respective optimal fiscal and Pigouvian taxes. The higher is the government's budget requirement, the less is the weight of the environmental element. Hence, the *environmental tax element* is only a share (1-*a*) of Pigouvian tax:

[2] $$Environmental\ tax = (1\text{-}a)\, MDC \leq MDC$$

Measuring environmental taxes in practice

The theoretical framework refers to an optimal situation where the optimal value of *a* is a simple function of the shadow prices on the public and the private budget constraints. Thus, *a* is the same for all goods and tax rates. In practice, the formulation of the tax system generally deviates from the theoretical framework due to market failures, conflicting political stands, pressure groups and other considerations than pure efficiency concerns. It is then not clear how one should decompose an observed tax rate into a fiscal contribution and the *MDC*. This is not an argument against using the general principles underlying the optimal tax structure as guidelines when evaluating the actual tax structure. It is hard to see how one can avoid some arbitrariness in the evaluations when using a theoretically optimal structure as a reference for the evaluation. The weighted average in [1] should be regarded as one such principle. Moreover, as this paper demonstrates, one can derive policy relevant conclusions concerning the actual tax structure without knowledge about the weights.

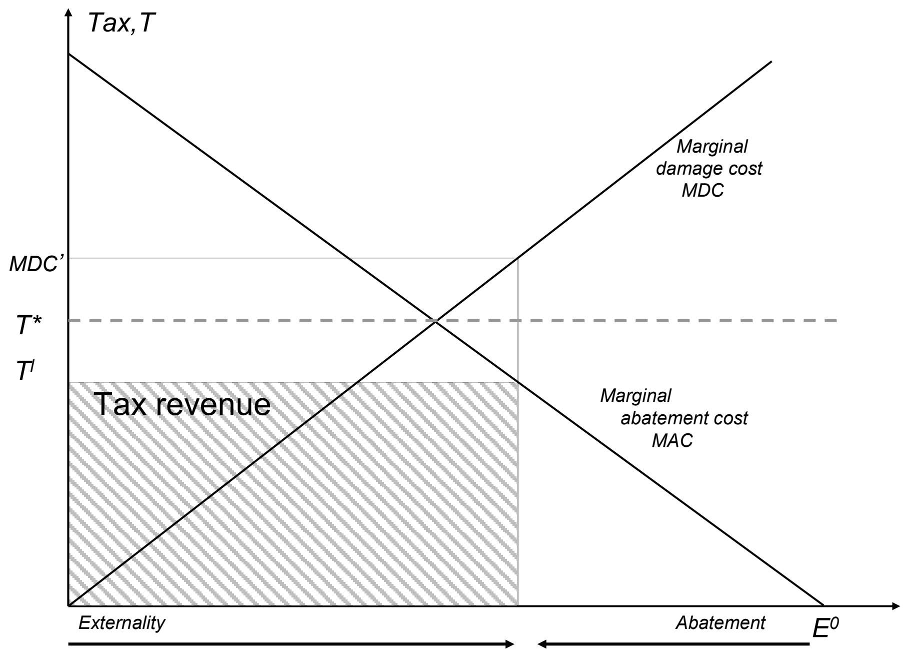
For the values of MDC, environmental economics theory has developed several methods for estimating environmental externalities (see e.g. Pearce and Turner 1990). As the values cannot be observed in the market, the estimates are only approximations to the true shadow prices, and they will vary depending upon the estimation method.

Given that optimal weight of the value of *a* for practical purposes is unknown, and that the implemented taxes are not well defined, there is a need for some principal guidelines as a basis for the calculations of the environmental tax elements [2].

We separate between two different cases. The first case is when the tax rate is set lower than T^*, the second when the tax rate is set higher than T^*, T^* being the optimal tax rate where $T = MDC$.

When $T = T^1 < T^*$, the tax is lower than marginal damage at the actual emission level, $T^1 <$ *MDC'*. This case is illustrated in figure 1 under the general assumptions of increasing marginal abatement costs and increasing marginal damage costs. Defining the entire revenue as environmental tax revenue is a strong assumption. This would imply that the marginal cost of fund is zero (a=0) and hence the Ramsey tax is zero in an optimal tax system. In practice, fiscal taxes are added to most Pigou taxes, and as shown in [2] the *environmental tax element* is lower than *MDC* at the actual emission level. Principally, it could even be lower than T^1. If the revenue from the tax T^1 is used as an estimate on the environmental tax element, it must be interpreted as an estimate for the *maximal* environmental tax revenue.

Figure 1. Tax lower than marginal damage cost

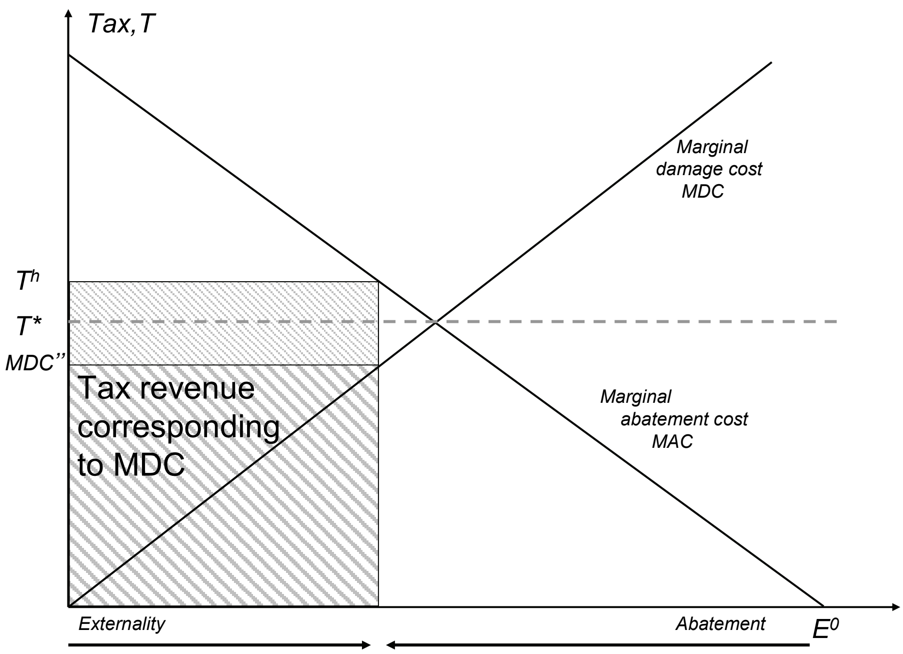


When $T = T^h > T^*$, the tax is higher than the marginal damage, $T^h > MDC''$, see figure 2. Then the revenue obviously includes more than the optimal Pigouvian tax equaling the marginal damage cost. Contrary to what may be perceived as standard intuition, part of the total revenue, i.e. *at least* $T^h - MDC''$, is to be classified as fiscal and subtracted from the revenue even if the tax is levied on an externality.

The next question is how much more should be subtracted to be ascribed to the fiscal element. As long as *a* in practice is unknown, we do not get more help from theory. As in the example above, to define the entire *MDC''* as the environmental tax is rather radical, since that implies that the marginal cost of fund (*a*) is zero, cf. [2].

Using *MDC* is hence to be interpreted as an estimate for the *maximal* environmental tax revenue.

Figure 2. Tax higher than marginal damage cost



To summarize, we recommend that existing estimates on the marginal damage costs *MDC* are used as estimates of the *maximum potential environmental taxes*. When the tax rates are higher than the *MDC*s, the difference should be subtracted from the revenue.

The international approximation to environmental taxes

Attempts have been made to compare the magnitude of environmental taxes in terms of *tax revenues* for several years (OECD 2006, Eurostat 2008). The guidelines are based on a statistics framework devised in 1997 by Eurostat, OECD and IEA (Eurostat 2001), referred to hereafter as the "Eurostat et al. definition". Varying definitions across countries and the complications in separating the environmental elements from the other taxes have influenced the guidelines for the collection of data. Consistency between national accounts and comparisons of environmental data was emphasized, in order to draw the data from the countries' national accounts. Consequently, practical concerns have separated the guidelines from stringent definitions of environmental taxes based on economic theory. Rather, Eurostat et al. "*decided to focus on the tax bases that have a particular environmental relevance, and to consider all taxes levied on these tax bases as environmental*" (Eurostat 2001).

The Eurostat et al. definition of an "*environmentally related tax*" is "*A tax whose tax base is a physical unit (or a proxy of it) of something that has a proven, specific negative impact on the environment. It was decided to include all taxes on energy and transport in the definition of environmental taxes. Value added type taxes are excluded from the definition* (Eurostat 2001). A more specified list of tax bases is included in the guidelines (see Appendix).

This definition covers principally any form of economic activity. All manufacturing requires factor inputs with negative environmental impact, and all taxes and charges will affect emissions by equilibrium effects. Hence, it is difficult to interpret these data, and in particular they cannot be taken as any reliable indicator of the use of environmental taxes, as the appellation "*environmentally related*" indicates.

The Eurostat et al. specified list of tax bases to be included (see Appendix) raises several questions. According to the Eurostat et al. definition above, all taxes on tax bases with a negative impact on the environment should be included, regardless if the taxes are fiscally motivated. In line with many of the taxes included in the Eurostat et al. definition, the fiscal value added taxes (VATs) on environmentally damaging products contribute to reduce supply of the products, and VATs on for example fossil fuels has the same kind of effect as the CO_2 tax on petrol. Hence, according to Eurostat et al.s *basic definition*, VATs and the environmental taxes should be equivalently treated. Still, an exception is made for the VATs by excluding them from the definition, not because they are fiscal taxes as would follow the theoretical principles outlined above, but because "they do not influence relative prices in the same way as other taxes on environmentally related tax bases" (Eurostat 2001). Notably, some VAT rates are also designed to influence environmental behavior. For instance, in Austria and Spain VAT it is higher on motor vehicles than other goods, and many of the fiscally motivated transport taxes included in the Eurostat et al. definition vary according to emissions.

Further, the Eurostat et al. definition includes taxes on resources. Resource taxes are usually imposed to tax economic rents on the extraction of natural resources (Ricardo rents, Hotelling rents and monopoly rents), they are not directed towards externalities. Neither do the resource taxes affect the extraction of the natural resources or are intended to do so. Hence, resource taxes should not be included in a measure of *environmental taxes*. Eurostat questions whether resource extraction is environmentally harmful in itself, though argue that it *can* lead to environmental problems, and concludes that this is sufficient reason to warrant its inclusion in the tax base (Eurostat 2001). This seems like an arbitrary argument.

In other cases, exceptions are made. Taxes on resources like oil and gas are excluded, as is the natural resource tax imposed on for instance Norwegian hydro power. Eurostat justify this by invoking the wide variation in revenue from taxing oil and gas and between national tax systems. This also seems like a rather arbitrary argument, and consequently, data is adjusted to avoid variation and to avoid that the revenues from some taxes exceed a certain size. This contrasts the purpose of estimating and comparing environmental taxes, which is to illuminate the variation in the use of instruments between countries and over time. These are examples of exceptions and lack of consistency that introduce interpretation and comparability problems.

It is an empirical question whether the international data following the Eurostat et al. definition is close to the actual environmental taxes. As argued above, the *MDC* estimates provide the maximum estimates of environmental taxes. If the reported taxes according to the Eurostat guidelines are significantly *higher* than this maximum measure, we may reject the international definition as an approximation to environmental taxes.

Environmental taxes compared with the Eurostat et al. definition

To investigate this matter, we calculate the *environmental taxes* and compare them with the *taxes following the Eurostat et al. definition*. Table 1 shows these numbers, using Norway as a case. We estimate the environmental taxes in 2007 to nearly 1700 million euro. The taxes following the Eurostat et al. definition and reported to the Eurostat/IEA/OECD database amount to 8200 million euro (Næss and Smith 2009).

Table 1. Real revenues from Norwegian environmental taxes and compared with revenues according to the Eurostat et al. definition, million Euro, 2007

	Real environmental tax revenues	Eurostat et al. tax revenues
Total	**1666**	**8228**
	Taxes on Greenhouse gases	
Tax on CO2 emissions from petroleum activity on the continental shelf	310	422
CO2 tax on mineral products	409	558
Tax on greenhouse gases HFC and PFC	28	28
Tax on final treatment of waste - CH4 element	17	85
	Other environmental taxes	
Petrol tax - environmental element	366	1015
Diesel tax - environmental element	289	802
Tax on final treatment of waste - other pollutants	12	0
Sulfur tax on mineral products	14	16
Tax on NOX emissions in the petroleum sector	61	61
Tax on NOX emissions	89	89
Tax on pesticides, trichloroethane and tetrachloroethane	9	9
Taxes on beverage containers	60	60
Other taxes reported by Eurostat:		
Motor vehicle registration tax		2827
Re-registration tax on motor vehicles		271
Annual motor vehicle tax		1012
Annual weight based tax on motor vehicles		44
Electricity consumption tax		748
Tax on mineral oils		85
Tax on lubricating oil		11
Base tax on disposable beverage packaging		83

The starting point for analyzing the Norwegian environmental taxes was all special duties[1]. We evaluated all these in light of the theoretical principles discussed above and existing marginal damage cost estimates.

Taxes on greenhouse gases

In Norway, *taxes on* CO_2 are levied on emissions from petroleum activity on the continental shelf, and on mineral products. In line with the theoretical discussion above, we use the marginal damage costs as estimates for the environmental element in the revenues from CO_2 taxes. Due to the nature of the problem of global warming, the *MDC* estimates are subject to particular uncertainty and variability. Using the price for emission permits in a carbon quota market is one approximation. Another estimate of the *MDC* could be the CO_2 tax. In practice, also this tax is highly differentiated, despite that the marginal damage is independent of source. For a large proportion of the sources for CO_2 emissions in Norway, the taxes are excessive relative to a cost-effective system determined by the market price of emission permits. As pointed out by Bruvoll and Larsen (2004), the highest tax rates are levied at tax bases with limited effect, while the sectors where the taxes would have been efficient are exempted. This indicates a heavy emphasis on the fiscal element for some emission sources, while the fiscal element is zero for other.

We have used 25 euros per tonne CO_2 as an estimate. This is in line with both the highest price of emission permits in the European Trading System in 2007 (www.pointcarbon.com), and the average Norwegian CO_2 tax, see Bruvoll and Dalen (2009). Bruvoll and Dalen (2008) calculate the average excessive fiscal component at 27 percent of the revenue from the Norwegian CO_2 taxes. Hence, we define 73 percent of the taxes on CO_2 as environmental taxes, amounting to 720 million euro. This should be interpreted as the upper boundary of the uncertainty interval at the given *MDC* estimate for climate gas emissions. The Eurostat statistics includes the entire revenue from the CO_2 taxes, amounting to nearly 10 billion euro, see table 1.

The taxes on the greenhouse gases *HFCs and PFCs* accord approximately to the same level as the average CO_2 tax, the highest level of the ETS price, and hence the *MDC* estimate for

[1] An environmental tax is a type of special duty. Special duties include environmental taxes, fiscally warranted special duties and taxes created for specific goods to reduce consumption. Indirect taxes include in addition to special duties VAT and customs duty. Source: Ministry of Finance (2007).

climate gas emissions as used for CO_2. The full revenue is thus included in our calculation. This corresponds to the Eurostat et al. estimate.

The *taxes imposed on the final treatment of waste* are intended to price the environmental costs of waste treatment, including the greenhouse gas CH_4, and to increase recycling and reduce waste amounts (Ministry of Finance 2007). The tax on landfills does not target the pollution but the amount of waste. Over the past few years, emissions per tonne of waste have fallen rapidly, but the tax per tonne of waste has remained the same without being adjusted according to theory. The marginal damage costs are estimated to be less than 25 per cent of the deposit tax (Bruvoll and Dalen 2008, Ministry of Finance 2007). We hence define the remaining as fiscal. The Eurostat et al. definition includes the entire revenue from these taxes, see table 1.

Other environmental taxes

The *taxes on petrol and diesel fuel* define usage-dependent external costs except climate gas emissions (Ministry of Finance 2007). The taxes include the cost of road usage and accidents in addition to environmental costs. The Eurostat et al. definition includes the entire revenue from these taxes. But to isolate the environmental component, the revenue related to road use and accident costs, and other non-environmental components should be subtracted. According to ECON (2003) and Ministry of Finance (2007), the marginal costs related to local emissions account for 8 per cent and noise for 28 per cent of the revenue from these taxes[2]. Using these estimates, we classify 36 per cent of the petrol and diesel fuel tax as environmental taxes.

The *tax on waste incineration* is adjusted to correspond to the estimated environmental damage (Ministry of Finance 2007). Hence, we define it an environmental tax. This is in accordance with the Eurostat et al. definition.

The *sulfur tax on mineral products* addresses environmental externalities associated with acid rain. Relative to the target set in the Gothenburg Protocol, the tax is 13 per cent higher than the necessary marginal abatement cost (Ministry of Finance 2007), cf. figure 2. We have corrected the revenue for this, while Eurostat et al. include the entire revenue.

[2] Price adjusted to 2007-level. The estimates for external costs for petrol fuel vehicles are used also for diesel fuel vehicles.

The *taxes on emissions of* NO_x address environmental externalities arising from NO_x emissions. The taxes are designed to meet agreed targets under the Gothenburg Protocol. The taxes are lower than estimated optimal tax to reach the emission target, $t < MDC$, cf. figure 1. Hence, we use the total revenue from these taxes as an estimate of environmental taxes on NO_x.

The *taxes on pesticides, trichloroethylene and tetrachloroethylene* address health and environmental costs. The Ministry of Finance considers that the taxes have contributed to fulfill its intentions with respect to emission reductions, cf. a reduction to the optimal level at $MDC=MAC$ in the figures above. Hence, we define these taxes as environmental taxes.

The *taxes on beverage containers* are intended to price the environmental costs of such containers that end up as waste in the natural environment. According to Raadal et al. (2003), differentiation by type of material reflects the environmental costs. Hence, we consider the taxes as estimates for environmental taxes.

Other taxes included in the Eurostat et al. definition

We estimate that almost 6600 million euro of the taxes included in the Eurostat et al. definition are not environmental taxes according to theory, see table 1. As discussed so far, compared to Eurostat we have excluded the fiscal elements related to the taxes on *CO_2 emissions* from petroleum activity on the continental shelf and mineral products, *final treatment of waste*, *petrol and diesel fuels*, and *sulfur*.

Some other tax bases are excluded from our definition in their entirety. The first four we mention are related to the transport sector, see table 1. The most important is the *motor vehicles registration tax*. The original purpose of this tax was to create revenue for the state. It is also progressive to address distributive considerations, though commercial vehicles are exempt, and differentiated on the basis of CO_2 emissions. While it is based on a criterion which would suggest an environmental impact, this is not sufficient to justify the tax as an environmental, i.e. Pigouvian, tax. As argued above, in principle all instruments influence the emissions through the equilibrium effects in the economy. First, to be defined a Pigouvian tax, the tax should be levied as close as possible at the externality, i.e. in this case at the emission or the fuel. The fact that the registration tax may slow the renewal of the car fleet, and hence increase pollution is a reminder of the necessity of a theoretical basis for the definition of environmental taxes. Second, the externalities related to transport are already internalized in the emission taxes mentioned above. Defining more taxes on the same externalities as environmental would imply a double counting. Hence, the motor vehicles registration tax is not to be considered an environmental tax.

Likewise, the *re-registration tax on motor vehicles* is independent of usage and has no direct connection with the emissions from transport. The *annual tax on motor vehicles* is higher for vehicles without particle filters, but is also independent of usage. The *annual weight based tax on motor vehicles* is intended to price local emissions and road wear. However, this is also a usage-independent tax, and it is not suited to correct usage-dependent external costs. These taxes will therefore not price road wear or local emissions correctly. In addition, the emissions from transport are already internalized in the carbon taxes and the taxes on petrol and diesel fuels. Hence, we do not consider these taxes as environmental.

The taxes associated with the transport sector amount to nearly 4200 million euro and represent the key source of error in the Eurostat et al. definition, cf. our estimate of the environmental taxes to 1700 million euro. Rather than adjusting for environmental externalities, the taxes are intended to fund infrastructure. The cost of road construction varies widely, compare mountainous countries as Norway and Switzerland with the flat terrain in Denmark and the north of Germany. Given that these taxes reflect infrastructure costs, these taxes would vary, without indicating differences in environmental priorities. Rather, increasing transport taxes to fund infrastructure may entail increased emissions from transport and a less environmentally friendly policy.

According to the Eurostat et al. definition, the entire *electricity consumption tax on electric power* is counted as an environmentally related tax. The political motivation is environmental and fiscal concerns, in addition to being an energy policy instrument (Ministry of Finance 2004). The tax is levied on the *consumption* of power. With the exception of some reports of el-allergy, its consumption has no known adverse environmental effect, and the consumption tax has therefore no environmental justification. On the other hand, the *production of power* does affect the environment. 100 per cent of Norwegian electricity production is hydroelectricity and wind power. Negative domestic externalities are associated with the construction and running of hydro-electric and wind power plants. The environmental impacts associated with constructing hydro-electric and wind power plants are addressed by the terms of the development concession agreement, conservation plans and general water systems plans. They cover in addition the environmental consequences of production, such as rotating windmills and reservoir drain down. Apart from these examples, it is difficult to spot negative environmental effects of domestic power generation. When importing electricity to Norway, CO_2 emissions and local pollution from coal-fired power plants may increase abroad. The responsibility for these emissions lies with the Swedish and Danish emissions accounting systems, the environmental policies and climate agreements in these countries.

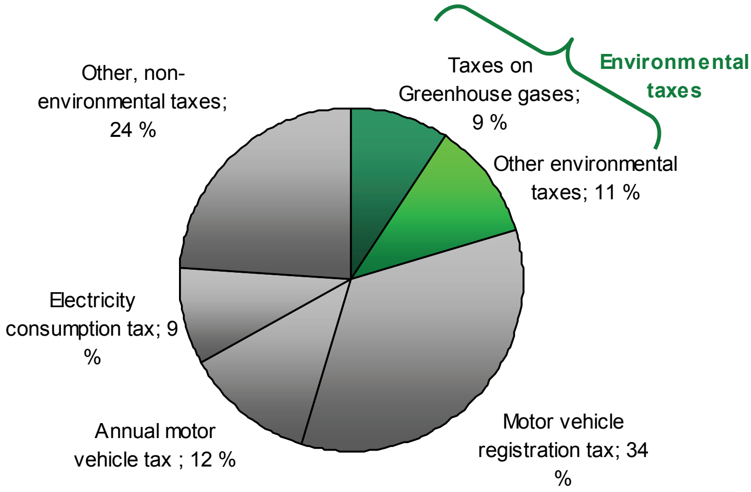
We thus conclude that the electricity consumption tax does not correct any environmental externalities. This tax is another example of the importance of following theoretical principles when defining concepts. Instead of being a Pigouvian tax, the electricity consumption tax may have the opposite function. As Norwegian power production is emission free, the power tax principally encourages substitution to fossil based heating sources and hence increased emissions. The tax could also lead to lower producer prices and lower profitability in the development and use of new, emission-free technologies.

The *tax on mineral oils* was introduced to prevent substituting oil for electric power. The tax is not imposed on the emissions, which would follow from the general principle of taxation, or determined on the basis of specified emissions. As a tax on fossil fuel emissions, it represents a double taxation, since the emissions are already regulated by taxes mentioned above. We follow the judgment of the Ministry of Finance (2007), that it should be considered in the way as the consumption tax on electric power, namely as a fiscal tax.

The *tax on lubricating oils* is not imposed on emissions from the use of such oils but is intended to fund a collection system and responsible handling of oil waste. Then, it should be considered a *charge*, covering the costs of abated emissions, not an environmental tax, covering the costs of the remaining emissions. It is hence intended to cover the abatement costs, not the emissions costs, cf. the figures above.

The reason behind *base tax on disposable beverage packaging* is the view that reuse is more environmentally friendly than recycling materials. According to Ministry of Finance (2007), there is little or no evidence of this, and it could even distort competition, and should therefore be withdrawn. Hence, this is not an environmental tax.

Figure 3. Norwegian special duties, 2007



Using Norwegian taxes as an example, we find that about 20 percent of the tax revenues following the principles outlined by Eurostat, IEA and OECD are environmental taxes, see figure 3. Estimating the use of environmental taxes and revenues requires careful examination of the set of special duties in light of tax theory, and detailed evaluation of each of the tax systems in all the countries over the entire data period.

Concluding remarks

In this article, we have discussed the theoretical basis for how to measure the use of *environmental taxes*. The optimal environmental tax, the Pigouvian tax, equals the marginal damage cost. We argue that when the tax rates on externalities are set higher than the marginal damage costs, the difference should be subtracted from the tax. And contrary to standard approximation, the environmental tax element is generally even lower than the Pigouvian tax in the presence of fiscal taxes.

We compare the theoretical approximation to the international framework defined by Eurostat, OECD and IEA (Eurostat 2001) for calculation of environmentally related taxes. The Eurostat et al. definition includes taxes related to environment, energy and transport together and hence aggregates fiscal taxes and environmental taxes in terms of a common measure. Even though the Eurostat et al. framework uses the term environmentally *related* taxes in their original definition, the term environmental taxes is used in reports of the international statistics (e.g. in European Environment Agency 2005, Eurostat 2008). This creates misleading interpretation to the users of the data.

Our empirical examination illustrates that even with a stringent definition based on theory, subjective judgments are hard to avoid when separating environmental taxes from other taxes. Even with a wide uncertainty interval, our comparisons with the environmental tax revenues following the theoretical definition shows that the Eurostat et al. definition is too wide to indicate the variation in environmental taxes. The perspective on the extent of environmental taxation in OECD is thus highly overrated. Consequently, scientists using the data may draw misleading conclusions on the causes and effects of environmental policy (see e.g. Morley 2009, Ekins 1999, Sterner and Köhlin 2003, OECD 2006) and the public is presented faulty information on the ranking of environmentally friendly policies over time and across countries. To improve the statistical framework of the reports on environmental taxes, the international guidelines should be revised based on economic theory.

Finally, it is debatable what information these tax revenues can offer, even if they are correctly calculated. A tax revenue is the product of the tax rate and the emission. Revenue growth could result from increasing awareness of the value of the environment (i.e., more or higher taxes), or from growth in emissions due to less stringency in environmental regulations. Also, if the elasticity of the emission with respect to the environmental tax is higher than one, the environmental tax revenue will increase as a result of *lower* environmental taxes[3]. It is then an open question whether revenue growth indicates a more or less environmentally friendly policy stance. Changes in the formulation of the tax systems may also give misleading signals. E.g. a switch from taxation to a quota system and emission permit trading will reduce the revenue from taxes, without having any practical impact on emissions or climate policy priorities.

Another problem is the interpretation of the tax revenues presented as percentages of gross domestic product, or as percentages of all taxes and charges (see, for instance, OECD 2006, Eurostat 2008). Falling tax shares could simply result from an increase in GDP without indicating any changes in political priorities. The revenue could also be influenced by

[3] The environmental tax revenue R equals the tax t times the emission $E(t)$. $R'(t) > 0$ only if $|(\delta E/E)(\delta t/t)| < 1$

adjustments in other parts of the tax system or structural changes in the economy, while keeping environmental policy unchanged. Rather, the variation in overall tax levels across countries partly expresses distributive policy priorities and the size of the public sector.

References:

Bruvoll, A. and H. M. Dalen (2008): Lag på lag i norsk klima- og energipolitikk (*Multiple climate and energy policies*), Økonomiske analyser 5, 29-37 (*in Norwegian*).

Bruvoll, A. and H. M. Dalen (2009): Pricing of CO_2 emissions in Norway, Documents 16, Statistics Norway.

Bruvoll, A. and B. M. Larsen (2004): Greenhouse gas emissions in Norway. Do carbon taxes work? Energy Policy 32(4), 493-505.

Bye, T. and A. Bruvoll (2008): Multiple Instruments to Change Energy Behaviour: The Emperor's New Clothes?, *Energy Efficiency* 1(4), 373-386.

Diamond, P. and J. Mirrlees (1971): Optimal Taxation and Public Production I: Production Efficiency. American Economic Review 61, 8–27

ECON (2003): Eksterne marginale kostnader ved transport (*Marginal external transport costs*), Rapport 2003-054, ECON Analyse, Oslo (*in Norwegian*).

Ekins, P. (1999): European environmental taxes and charges: recent experience, issues and trends, Ecological Economics 31, 39–62.

European Environment Agency (2005): Market-based instruments for environmental policy in Europe, EEA Technical Report, No 8.

Eurostat (2001): Environmental taxes – A statistical guide. Office for official publications of the European Communities, Luxembourg.

Eurostat (2008): Taxation trends in the European Union. Data for the EU Member States and Norway, Eurostat Statistical Books, 2008 Edition.

Ministry of Finance (2004): Differensiert el-avgift for husholdninger (*Differentiated household electricity taxes*), NOU 2004:8 (*in Norwegian*).

Ministry of Finance (2007): En vurdering av særavgiftene (*An evaluation of excise taxes*), NOU 2007:8 (*in Norwegian*).

Morley, B. (2009): Environmental Taxes, Renewable Energy and Economic Growth: Empirical Evidence from Europe, Presentation at The 66th International Atlantic Economic Conference Montréal, Quebec Canada, http://iaes.confex.com/iaes/IAES66/techprogram/P2382.HTM.

Næss, E. M and T. Smith (2009): Environmentally related taxes in Norway. Totals and divided by industry, Documents 5, Statistics Norway.

OECD (2009): Database on environmental policy instruments, www.oecd.org/env/policies/database.

OECD (2006): The political economy of environmentally related taxes, ISBN 92-64-02552-9.

Pearce, D. W. and R. K. Turner (1990): Economics of natural resources and the environment, Harverster Wheatsheaf, Ashford colour Press Ltd, Gosport, Hampshire.

Pigou, A. C. (1920): The Economics of Welfare, London, Macmillian.

Ramsey, F. (1927): A Contribution to the Theory of Taxation, Economic Journal, March, 47–61.

Raadal, H. L., C. A. Nyland, I. S. Modahl and O. J. Hanssen (2003): Miljøvurdering av gjenvinnbare og gjenvinnbare PET-flasker brukt som drikkevareemballasje i Norge (*Environmental valuation of recyclable PET drinking bottles in Norway*), OR 10.3, Stiftelsen Østfoldforskning, Norway (*in Norwegian*).

Sandmo, A. (1975): Optimal taxation in the presence of externalities, Swedish Journal of Economics 77, 86-98.

Sandmo, A. (2000): The Public Economics of the Environment. Oxford: Oxford University Press.

Sterner, T. and G. Köhlin (2003): Environmental taxes in Europe, Public Finance and Management 3(1), 117-42.

Appendix:

The Eurostat (2001) “Tax bases included in the environmental tax statistics framework”:

Measured or estimated emissions to air
- Measured or estimated NO_x emissions
- SO_2 content of fossil fuels
- Other measured or estimated emissions to air

Ozone depleting substances (e.g. CFC or halon)
Measured or estimated effluents to water
- Measured or estimated effluents of oxydizeable matters (BOD, COD)
- Other measured or estimated effluents to water
- Effluent collection and treatment, fixed annual taxes

Certain non-point sources of water pollution
- Pesticides (Based on e.g. chemical content, price or volume)
- Artificial fertilisers (Based e.g. on phosphorus or nitrogen content or price)
- Manure

Waste management
- Waste management in general (e.g. collection or treatment taxes)
- Waste management, individual products (e.g. packaging, beverage containers)

Noise (e.g. aircraft take-off and landings)
Energy products
- Energy products used for transport purposes
- Unleaded petrol
- Leaded petrol
- Diesel
- Other energy products for transport purposes (e.g. KPG or natural gas)
- Energy products used for stationary purposes
- Light fuel oil
- Heavy fuel oil
- Natural gas
- Coal
- Coke
- Biofuels
- Other fuels for stationary use
- Electricity consumption
- Electricity production
- District heat consumption
- District heat production

Transport
- Motor vehicles, one-off import or sales taxes
- Registration or use of motor vehicles, recurrent (e.g. yearly) taxes

Resources
- Water abstraction
- Extraction of raw materials (except oil and gas)
- Other resources (e.g. forests)