Distributional implications of environmental taxation in Denmark

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Abstract

Environmental taxes imposed on households have been introduced in many countries. However, few countries have reached the level of environmental taxation that is seen in Denmark today, although many are considering shifting the tax burden towards the consumption that is harming the environment.

The total tax burden imposed on households in Denmark in the form of taxes on energy use of all kinds, water consumption and waste production, etc., is considerable. This paper analyses the individual taxes as well as the combination of all these taxes and duties related to environmental concerns, including taxes on heating, transport fuels, electricity, water, waste, plastic bags, registration of cars, annual car use, pesticides, etc.

The distributional effect of taxes is examined in relation to household income, socio-economic class, residential location and family status. The shifting of the tax structure from high marginal income tax to consumption-based taxes, especially environmental taxes, might have distributional impacts amongst income groups which have not been considered part of the tax policy.

The taxes are compared with respect to distributional impact. Do the effects of the different taxes vary to such an extent that this should be considered when designing tax policies? The hypothesis is that some environmental taxes associated with luxury income are less regressive than the average environmental tax. The results suggest that in Denmark taxes on petrol and registration duties for cars are progressive, whereas most other environmental taxes are regressive, especially the green taxes on water, retail containers and CO_2.

The distributional impacts are illustrated using household consumption survey data and data covering household expenditures on energy. The energy taxes and the more recently introduced green taxes are compared.

***Keywords**: Environmental tax, distribution, empirical analyses, micro data*

***JEL**: Q3; Q48; H23;D3*

1. INTRODUCTION

Environmental concerns have contributed to a widespread use of environmental taxation in many countries. Ekins (1999) surveys the environmental taxes and charges implemented in Europe. The amount of revenues generated by these taxes is still relatively small, but it is

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rising as a proportion of total taxation. This increase in environmental taxation has raised some concern over the distributional impacts of such taxes. The OECD (1994, 1995) examine distributional effects of environmental policy in a broad context including both theoretical results as well as empirical findings on distributional effects caused both by the taxation and by a reduction of environmental pressure. Bovenberg (1998, 1999) and Bovenberg & van der Ploeg (1998) examine environmental tax reform and its consequences for employment and welfare in a theoretical context.[1] These papers point to the difficulty of achieving both efficiency and distributional objectives through environmental tax reform.

Empirical findings[2] for Europe by Pearson and Smith (1991) suggest that carbon taxes tend to be more regressive in northern European countries than in southern European countries. This is due partly to taxes on petrol, which tend to be more progressive in southern Europe than in northern Europe, and partly to the climate-induced necessity for heating in northern Europe. Taxes related to motor vehicles are found to be neutral (Smith, 1995) in Europe on average, whereas there is evidence that petrol taxes in the US can have regressive effects, especially if considered in rural areas. Walls and Hanson (1999) compare four different taxes on private vehicle use in California. They find, based on a lifetime income proxy, that annual vehicle value taxes are mildly regressive, but that introducing more pollution-dependent taxation will increase the regressivity.

Poterba (1991a), amongst other things, compares the actual income measure with a lifetime income measure. The findings suggest that using lifetime income measures for distributional analyses produce less regressive tax results than using current income. Especially for low-income households, the choice of income measure is important because many households with low current incomes are students or pensioners with higher lifetime income.[3] Poterba (1991b) specifically analyses a petrol tax in the US that is found to be much less regressive if calculated using lifetime income.

Most empirical analyses examine distributional effects of taxes through their direct impact on household tax payments. A number of studies examine also the indirect effect via household consumption of goods that have been levied with environmental taxes in their production.[4] The general finding of these studies is that environmental taxes are regressive.

We examine the empirical evidence for the broad range of environmental taxes in Denmark. The paper addresses the issue from an empirical angle, examining the size and composition of Danish environmental taxation and the distributional effect of increased use of environmental taxes in Denmark. The distributional analysis is based on a combination of household expenditure surveys and samples drawn from governmental registries.

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[1] Pirttila and Tuomala (1997) analyse the same problem in analytic models with two types of households: low-ability and high-ability households. Their findings conclude that in specific cases an environmental tax can be an indirect tax on leisure. High-ability households are assumed to consume more leisure, so the environmental tax could therefore be neutral or even progressive.

[2] Speck (1999) includes a survey of empirical results on distributional implications of carbon and energy taxes, including most of those referred to in this paper.

[3] Contrary to this, Smith (1992) concludes that the choice between current and lifetime income has only modest influence on the distributional effects of energy and carbon taxes in the UK.

[4] Symons et al. (1994) use an input-output approach for a study of carbon taxes in the UK, and in Symons et al. (1997) the analysis is extended to cover a number of European countries. Input-output based studies have also been carried out for Australia (Cornwell and Creedy, 1996 and 1998), Canada (Hamilton and Cameron, 1994) and Spain (Labandeira and Labega, 1999).

2. THE EXTENT OF ENVIRONMENTAL TAXATION IN DENMARK

The amount of government revenues derived from environmental taxation in Denmark has been gradually increased in recent years. Green tax reforms initiated in 1993/1994 introduced new environmental taxes and increased existing taxes on energy. Table 1 shows the composition of the new "green" environmental taxes and other environmentally related taxes.

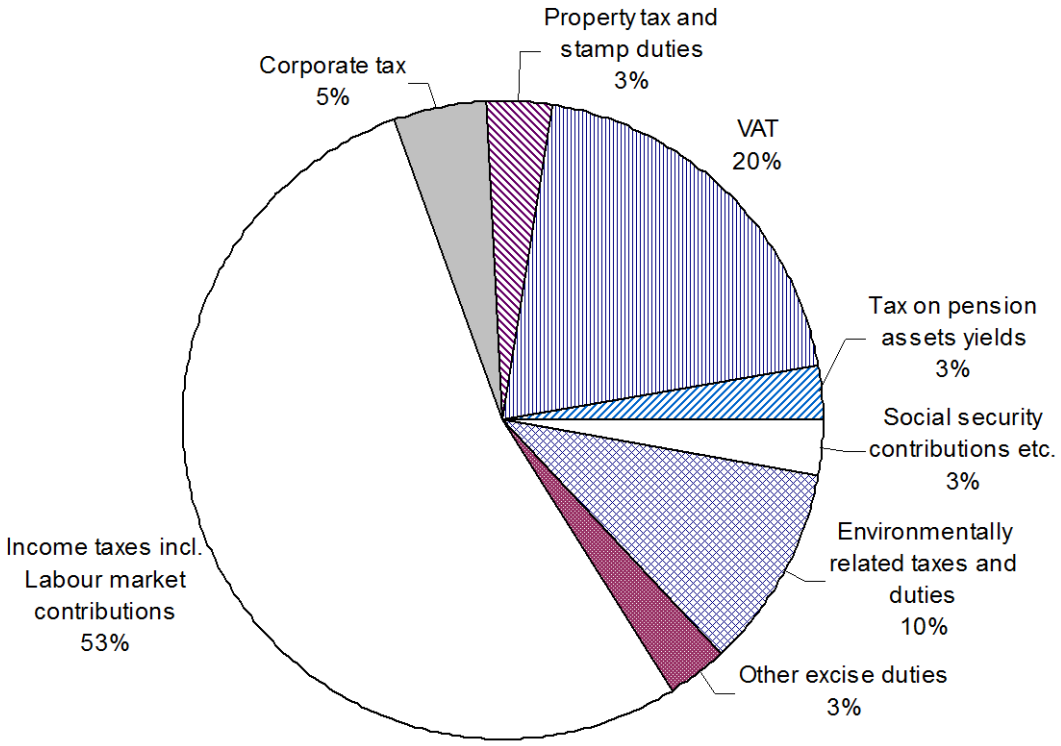
Table 1 Governmental revenue from energy and environmental taxation (millions Euro)

Type of duty	1995	1996	1997	1998	1999*	2000*
CO_2	440	507	535	555	620	637
Sulphur	0	45	51	50	77	64
Extraction of raw materials	18	18	19	21	21	25
Waste	83	81	116	119	154	134
CFC	0	0	0	0	0	0
Insecticides, herbicides, etc.	4	28	32	40	48	50
Disposable tableware	8	8	7	8	7	8
Carrier bags, retail containers, etc.	64	70	73	108	127	97
Piped water	98	143	179	207	218	231
Nickel/cadmium batteries	1	6	5	4	5	3
Chlorinated solvents	0	1	0	0	0	0
Effluent charges	0	0	22	37	37	40
Specific growth stimulants	0	0	0	2	6	2
Nitrogen	0	0	0	1	3	5
PVC and phthalates	0	0	0	0	0	8
Green taxes	**717**	**904**	**1041**	**1153**	**1323**	**1304**
Electricity	596	686	744	936	926	1026
Coal	85	90	95	106	201	262
Coal-based gas	7	7	9	0	0	0
Natural gas	0	2	2	16	161	379
Certain petroleum products	776	836	782	837	808	966
Electric bulbs, fuses, etc.	22	21	21	23	22	23
Energy taxes	**1486**	**1642**	**1653**	**1918**	**2118**	**2656**
Green taxes and energy taxes	**2203**	**2546**	**2694**	**3071**	**3441**	**3960**
Weight duty	591	660	694	730	832	885
Registration duty	2008	2061	2196	2454	2333	2145
Duty on third party liability insurance	127	143	179	180	188	195
Petrol	1003	1107	1155	1185	1288	1362
Flight passenger duty	31	35	37	59	58	64
Transport-related taxes and duties in total	**3760**	**4006**	**4261**	**4608**	**4698**	**4651**
Total environmentally related taxes and duties	**5963**	**6552**	**6955**	**7679**	**8139**	**8611**

There are a large number of environmental taxes included in Table 1 that are potentially influencing the amount of consumption or emissions. However, only a few of these were

* Figures according to Fiscal Budget (FL 2001)

originally introduced for environmental purposes. The majority of these fiscal duties and others were introduced as "luxury" taxes. They can however be seen as environmental taxes, for example, in the case of electricity where the high Danish tax definitely reduce consumption and the fuels used for producing the electricity at the same time is exempted from taxation. The "new" environmental taxes constitute only 1.3 billion Euro, corresponding to 15% of the taxes characterised as environmentally related. Around 45% of the environmental taxes are duties imposed directly on the use of energy products and an additional 8% are imposed on the emissions from energy use. The transport-related taxes, which constitute another major group of taxes, affect the environment by reducing petrol demand directly and by reducing the demand for privately owned vehicles.



Source: Fiscal Budget 2000, Ministry of Finance

Figure 1 Taxes and duties from different sources in Denmark 1999

Environmentally related taxes have grown in importance for total tax revenues in recent years. In 1999 environmental taxes constitute 10.4% of the taxes included in the above figure compared to 9% in 1995 and 7% in 1990. In the long term the revenue share of environmentally related taxes has only increased from 7.7% in 1980 to 10.4% in 1999,[5] with the increase occurring in the latter part of the nineties. Of the environmental taxes, the green taxes have risen the most, corresponding to 1.1% of taxes in 1995 and 1.7% in 1999. However, these new green taxes are still of limited revenue importance compared to the traditional

[5] Ministry of taxation (1998) Appendix 1 (p. 34)

energy taxes and private vehicle taxation. Environmental taxes in total contribute more to total revenues than the sum of corporate taxes and social security contributions.[6]

There is the important difference between the new green taxes and traditional energy taxes that most of the green taxes are paid by both consumers and producers, some even primarily by producers, whereas the producing sectors have been exempted from energy taxes and partly from registration duties. This has been defended because of concern for the international competitiveness of Danish producing sectors. In 1998 around 80% of the total environmentally related taxes were paid directly by consumers compared to around 60% of the new green taxes.

Table 2 Distribution of taxes in selected countries 1996

Percentage of total tax revenue 1996	Den mark	Norway	Sweden	Nether-lands	Finland	USA	EU
Personal income taxes	53.2	26	35.3	17.5	35	37.6	26
Other income and profit taxes	7	10.5	5.6	9.5	6.7	9.6	8.1
Labour market contributions and subscriptions	3.1	23.3	29.8	39.6	25.8	24.7	28.9
Taxes on wealth, real property, etc.	3.7	2.8	4.1	5.9	2.3	13	4.6
General sales taxes, customs duties	19.9	21.6	13.9	17.4	18.2	8.8	18.3
Duties on specific goods and services, fees	13.1	15.8	11.2	10.1	12.1	6.4	14
- of which environ-mentally related	**8.8**	**10.5**	**5.6**	**8.1**	**6.4**	**2.6**	

Source: Taxes and duties 2000, Statistics Denmark Table 9.6, OECD Revenue Statistics 1965-1996

Table 2 shows that Denmark is not outstanding with respect to the extent of environmental taxation compared to other countries traditionally associated with environmental concerns. The main difference in tax structure is not due to difference in environmental taxation, except for the US, which has lower duties on specific goods (including environmental taxes) and lower general sales taxes, etc. The main difference of the Danish tax structure is due to the financing of social security by total tax revenue and not by employers' contributions to social security, as in most other countries.

The distributional aspect of environmental taxation have been a major issue in the international debate over carbon taxes and has also been discussed in many countries in relation to energy and petrol taxes. In Denmark, however, this debate has been less intense, and the assumption of government transfers securing the distributional concerns has been generally accepted. A few tax exemptions for pensioners have been made,[7] and recently a proposal for a tax-free consumption threshold for energy taxes has been discussed.

In Denmark there is only a flat value-added tax rate; no reduced rate has been introduced for basic needs such as food and energy. This reflects the fact and generally accepted assumption that the income tax system and government transfers assure the necessary redistribution of income sufficient to purchase basic needs. Also, the fact that heating expenses for low-income households have been reduced by public urban renewal, which has supplied these households with relatively cheap district heating, is another explanation for the limited debate on energy taxes and distribution.

[6] In Denmark social security is mainly financed from government tax revenues.

[7] Compensation for heating expenses has been transferred to certain groups of pensioners.

3. DATA AND METHODOLOGY

Data for 1997, collected by the former Danish Ministry of Economic Affairs and covering around 3.3% of the Danish population, is the main data source for the analysis. A range of socio-economic variables and detailed tax monitoring information as well as public transfers are included in the data for each person and household. For a description of the data and its use, see Ministry of Economic Affairs (2000). The comprehensive data and the systematic treatment of it is referred to as the "Law model", which is used in the Danish ministries for examining distributional aspects and revenue consequences in relation to both existing and proposed legislation. We use an extract from this source in combination with extracts from data sources covering household energy consumption.[8] The data is combined with the household expenditure survey of Statistics Denmark (1999), that covers a much smaller sample of households[9] but includes information on environmental taxes not covered by the other sources. The survey is based on registrations from 2 weeks distributed over a calendar year followed by interviews and combined with certain administrative registers. For some of the goods and especially for some of the taxes, the uncertainty can be quite large. In some cases the households did not have the knowledge on tax payments.[10] For some taxes, such as registration duties and duties on coal and coke, the number of households in the survey that actually purchased these items was rather limited.

This paper concentrates on already implemented taxes and actual tax payments by households, whereby a behavioural response to the taxes will be reflected in actual tax payments. It is, however, more difficult to describe the consequences for households if there were no such taxes, or to predict the consequences of a new tax.

The wide coverage of the data source allows us to group individuals according to income, socio-economic class, family size, residential location, etc. The main focus is on the relation between income and tax payments, and therefore the individuals in the sample are grouped in income deciles with approximately 14000 in each. All adult persons in the sample are referred to income deciles based on the disposable income of their households.[11] In order to take into account different household sizes the aggregate income of the household is first transformed using age groups in the household.[12] The transformed income is then divided on the adults in the household. In appendix A the most central variables for income, etc., are given for the deciles.

The choice of income variable for constructing deciles is not straightforward, which is demonstrated by the findings of Poterba (1991a) and Metcalf (1998). They find that choosing the current income relative to lifetime income or a lifetime proxy such as current expenditure could produce different results. The regressivity in their results is less

[8] Data for electricity, water and natural gas consumption has been collected from supply companies, and covers between 20 and 50% of the individual households in the 3.3% sample.

[9] The survey uses a sample based on 1500 households for three consecutive years.

[10] For example, the tax on carrier bags and retail containers has to be calculated based on the purchase of other goods.

[11] In this way each decile include 13,846 adults in the 3.3% percentage sample used for green taxes and transport-related taxes. The larger sample, based on a 10% of the population, has 40,900 adults in each decile.

[12] The equivalent term (number of adults)$^{0.8}$ + ½(number of children)$^{0.8}$ is used following the Ministry of Finance. The weights in the Danish household survey are based on OECD and slightly different; 1 * first adult + 0.5 * following adults + (0.3 * children < 15 years). Both weights assume scale effects in consumption. The main difference is that the weight for young children is relatively higher in the Ministry of Finance term and the scale effect a little less pronounced than in the household survey.

pronounced when a lifetime income measure is used. Therefore, we also use total expenditure[13] to compare the results on distributional impact. Because the expenditure data except from energy and water are based on the household survey they only cover around 5000 persons compared to 140.000 for the income data[14]. In Appendix B distribution measures including three different income variables are given, one of which is based on current expenditure as a proxy for lifetime income.

The distributional impact of environmental taxes can be examined by looking at tax payments relative to disposable income for the deciles. A falling share of income used for environmental taxes with rising income indicates a regressive tax. If the share is steadily rising with income, the tax is seen as progressive[15]. The graphical representation, however, cannot be decisive if the share is not steadily rising or falling with income. Neither is it possible to directly compare the regressivity of different environmental taxes. Therefore, we use a simple measure for distributional impact based on the Gini coefficient.[16] We use the change in Gini coefficients as a result of additional tax collection following the method applied by Jørgensen and Pedersen (2000). The change in Gini coefficient is calculated after collecting an additional 13.4 million Euro (100 million DKK) in environmental taxes. This is a marginal revenue corresponding to less than 0.2‰ of total tax revenue.

The changes in Gini-coefficient will be used to compare the distributional effect of different environmental taxes. An increase in Gini-coefficient will be used to indicate a tax effect that increases inequality of consumption possibilities whereas a reduction of Gini-coefficient will indicate a tax that reduce inequality.

[13] Data from the household survey.

[14] Comparing expenditure and income data result in consumption ratios that seems quite high for the lowest income decile (180%), but the average consumption ratio is 95% which is as expected.

[15] The term "progressive" only refers to tax payment out of disposable income. The tax is not necessarily progressive as normally referred to an increasing **tax rate** for increasing income levels. All the environmental taxes included in this study are flat rates independent of income levels.

[16] This is done even though the Gini coefficient is known to have the disadvantage of giving high weights to the middle-income deciles.

4. DISTRIBUTIONAL IMPACT OF ENVIRONMENTALLY RELATED TAXES

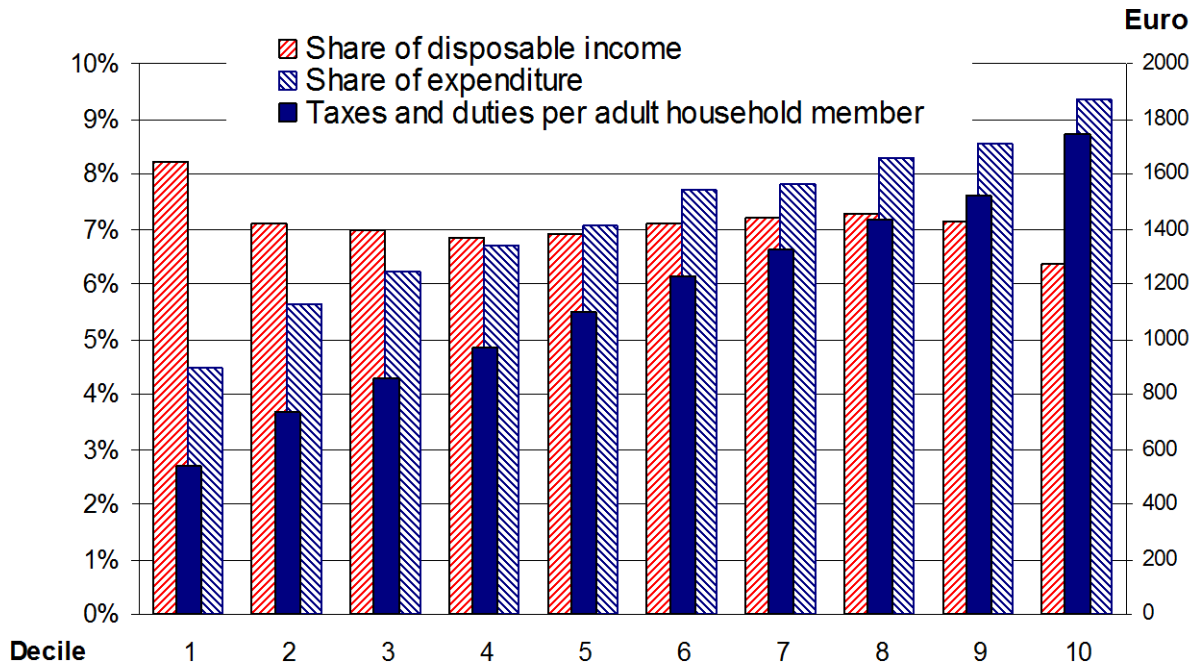


Figure 2 Environmental taxes and disposable income deciles

International studies such as those referred to in the introductory section find a tendency towards regressive effects for energy and carbon taxes. Most of these studies examine possible effects of CO_2 taxes and they produce mixed results for countries with different production and consumption characteristics. This paper attempts a broader perspective, firstly by looking at the combined effect of all environmentally related taxes and secondly by comparing the effect of different environmental taxes. It also distinguishes itself by analysing an implemented CO_2 tax that differs between energy use in households and industry and not fully reflects the carbon content[17].

Figure 2 shows the aggregate level of environmentally related taxes imposed on each income decile both in absolute terms (DDK per adult) and as a share of disposable income. The tax relative to total expenditures in the income decile is also given. The left vertical axis shows the share of these taxes out of disposable income and expenditure, whereas the right vertical axis shows the tax payment per adult. First the share of environmental taxes relative to income is only slightly different within deciles 2-9, but those in the lowest income decile use about 1¾ percentage point more of their income for environmental taxes than do those in the highest income decile. For the expenditure shares the figure reveals that the fraction of expenditures used for environmental taxes is increasing with income.

From these aggregate figures there does not seem to be an alarming problem with the distributional effects of environmental taxes, even though the taxes tend to be mildly regressive if seen relative to disposable income. The expenditure shares indicate that if expenditures is a proxy for life-time income and the consumption composition is

[17] CO_2 tax for electricity is 1.34 Euro-cent/kwh for electricity in households but effective rate for some heavy industries is only around 0.13 Euro-cent/kwh.

independent of the stage of life, then high income groups will use a higher fraction of "life-time income" for environmental taxes[18].

This result, however, does not tell the full story, as the aggregate environmental taxes do hide the very large difference that exists between green taxes and transport-related taxes. Figure 3 clearly distinguishes the effects between the main subcategories of environmental taxes.

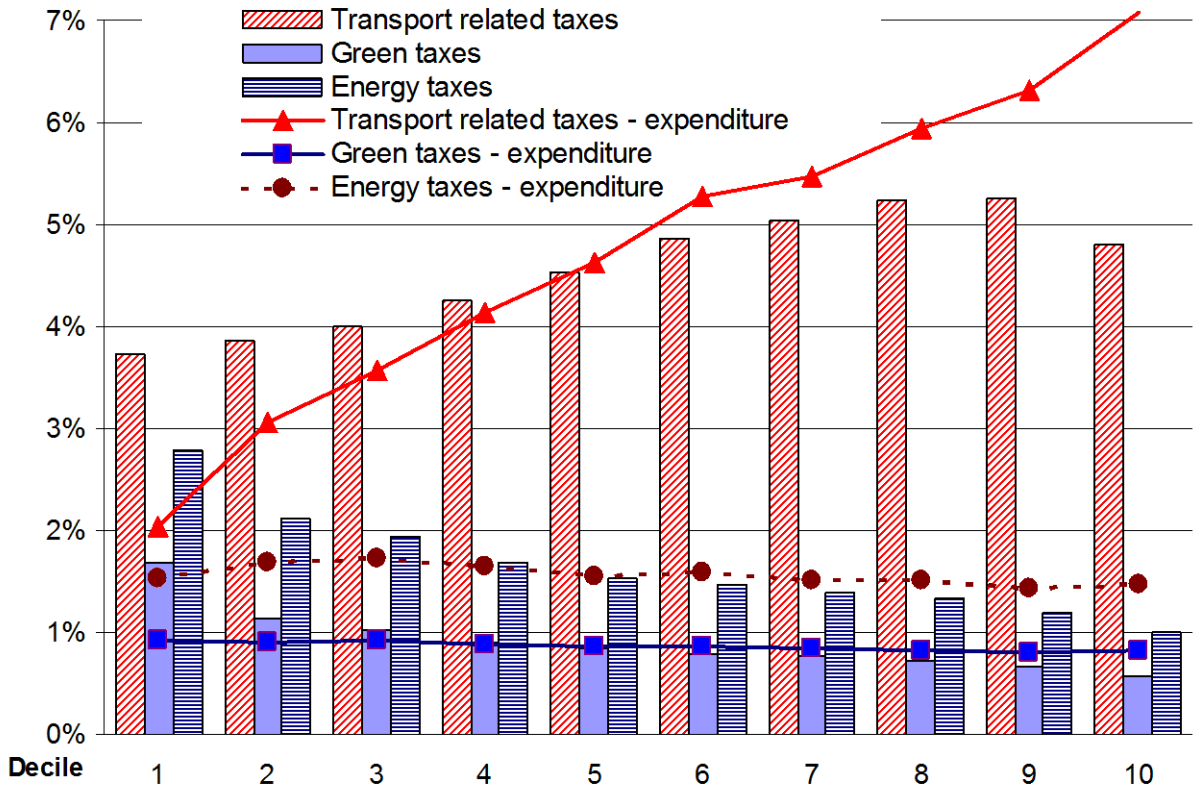


Figure 3 Major categories of environmental taxes (share of disposable income/ expenditure)

As Table 1 reveals, this paper also includes registration duties on new vehicles amongst environmental taxes. This is because this duty, even though it was not originally introduced in Denmark as an environmental tax, has certainly contributed to reducing the number of privately owned cars, the average car size and the amount of pollution associated with driving.

The figure compares the distributional effect of the three aggregate types of environmental taxes. Transport-related taxes increase with income except for the last decile, whereas green taxes and energy taxes both decline in importance with rising income, indicating a regressive tax effect. This tendency is seen for tax shares relative to both current income and total expenditure, but for the shares based on expenditure the distribution effect is generally less unfavourable to low income groups.

[18] Expenditure composition is not constant during the different phases of life. Transport-related taxes are higher around middle-age (high current income) and therefore the measure of tax shares using expenditure will tend to overestimate the life-time transport-related tax share of total income/expenditure. The measure using **current** income on the other hand underestimates the average life-time tax share of **life-time** income for high-income groups due to the high savings rate of current income.

In order to investigate the relative redistribution effect of green taxes and compare to taxes on energy and to determine if transport-related taxes are redistributing towards lower income groups the changes in Gini coefficients are calculated and applied in a later section.

The comparison of the three categories in Figure 3 leads to the conclusion that the green taxes and energy taxes on average are regressive to neutral in contrast to transport-related taxes, which are progressive. Transport taxes correspond to nearly 50% of the total environmental taxes paid by households, which is the main reason that, overall, environmental taxes only seem to be slightly regressive or even progressive in the case of expenditure shares. The findings of Speck (1999) and Symons et al. (1997) - that the effects of carbon and energy taxes are more regressive in the northern European countries than in southern Europe - corresponds to the data for Denmark analysed here.[19] The result for transport also corresponds to the findings of Smith (1995), who found transport fuel taxes to have no regressive effect in the English case. For the US the results are somewhat different, as Walls and Hanson found value-based registration duties to be mildly regressive.

5. ENVIRONMENTAL TAXES AND SOCIO-ECONOMIC CLASSIFICATIONS

The socio-economic characteristics of households are another important classification to examine with respect to the burden of environmental taxes. Two issues are in focus here: first, the relationship between residential location and tax burden is considered from the hypothesis that the environmental taxes constitute a higher fraction of income in rural areas; next, we examine the relationship between environmental taxes and socio-economic groups based on labour market status.

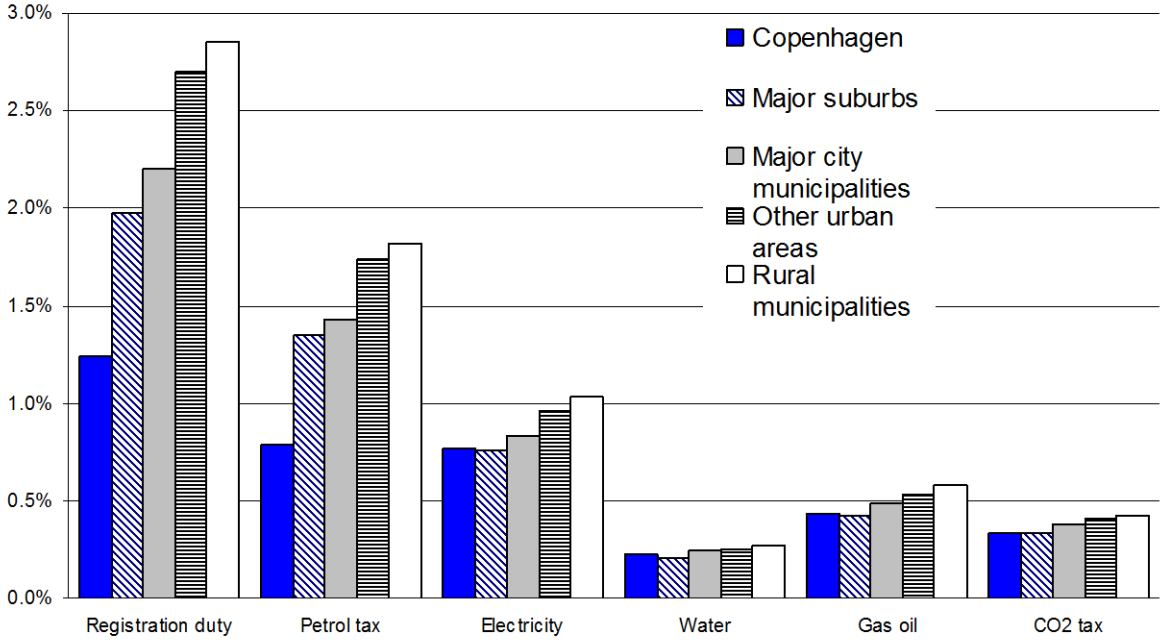


Figure 4 Residential location and selected environmental taxes (share of disposable income)

[19] This is a combination of a larger share of energy consumption in northern Europe and a more regressive pattern of this consumption (heating).

Rural households[20] pay a higher proportion of their income on environmental taxes than households located in cities. This goes for all taxes included in Figure 4, and the relation between residential location and tax payments also shows that the further the distance from the main cities, the larger the proportion spent on these taxes. This is especially pronounced for registration duties and petrol taxes, reflecting the facts that public transport is not available at the same scale in rural areas as it is in urban centres, and that populations in rural areas are more widely dispersed and thus depend on transport more than city dwellers. A similar explanation can be given for the more widespread use of gas oil and electric heating, as district heat and natural gas grids are less common in rural areas. The general conclusion is that the impact on rural households from environmental taxes is higher than for other parts of the population.

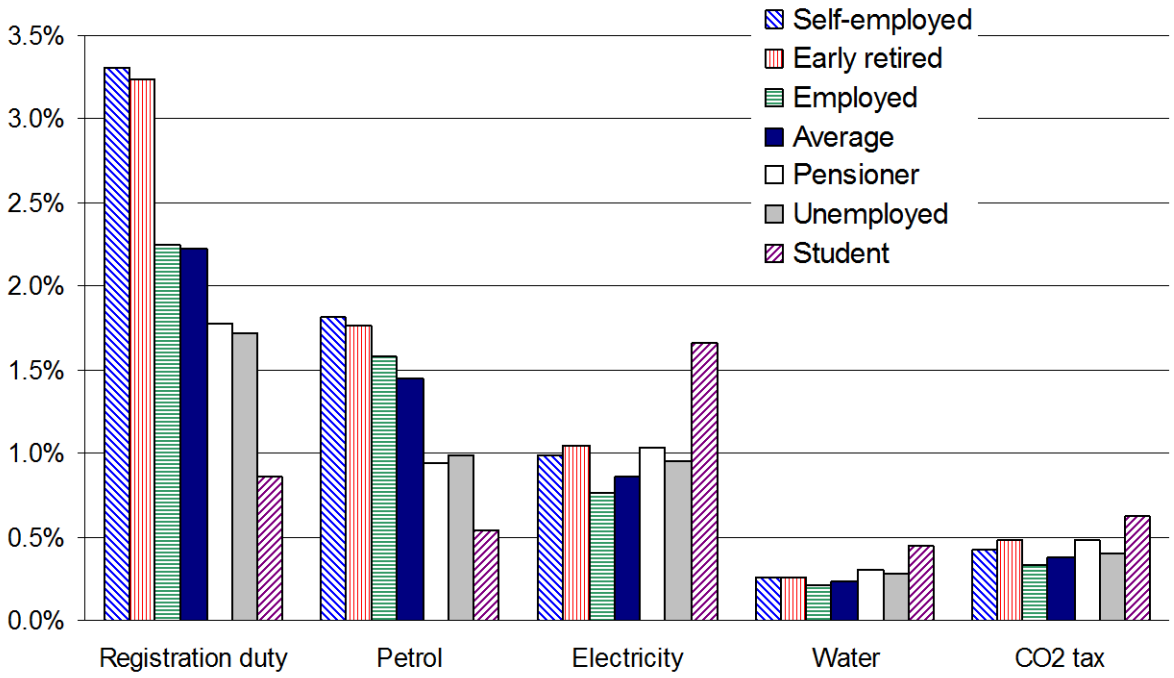


Figure 5 Socio-economic groups and environmental taxes (tax share of disposable income)

It could be assumed that environmental taxes put an excess burden on poorer groups, such as the unemployed or pensioners. However, this hypothesis is not supported by our data, and the groups with the largest environmental tax burden in Figure 5 are not those traditionally perceived as exposed population groups. The unemployed pays only a little larger share on electricity, water and carbon tax than the average household, and for petrol and registration duty they spend considerably less. Pensioners are very similar to the unemployed in this respect, but use slightly more on electricity and CO_2 taxes. The socio-economic classes affected the most seem to be early retired[21] and self-employed, which are the two groups that spend the largest fraction of income on registration duty and petrol.[22]

[20] Rural households constitute 181,000 households (7.3%) of a total of 2,466,000 households in Denmark and have a disposable income per adult 5% below the average income.

[21] This category refers to people receiving *efterløn*, a publically funded early retirement scheme.

[22] Because these taxes are the two largest, early retired and self-employed will also be the two groups with the largest share spent on environmental taxes in total.

Students are paying a higher share of income for electricity, water and CO_2 taxes than the average, but this is balanced by less than average payments for registration duty and gasoline tax. Students are the only group that would have shown a different burden if expressed relative to expenditure. This group has a considerable negative savings rate, whereas the other groups have savings rates close to zero. Students are thus less severely hurt by taxes on electricity, water and CO_2, than indicated in Figure 5.

The "weak" socio-economic classes are not the groups most hurt by the environmental taxes. The major explanation for this is that income is not much lower for weak groups and they spend much less on transport-related environmental taxes.

6. REDISTRIBUTIONAL EFFECT MEASURED BY CHANGES IN GINI COEFFICIENTS

The method of using calculations of distributional impact based on change in Gini coefficient from additional tax collection was briefly described in the section on methodology.

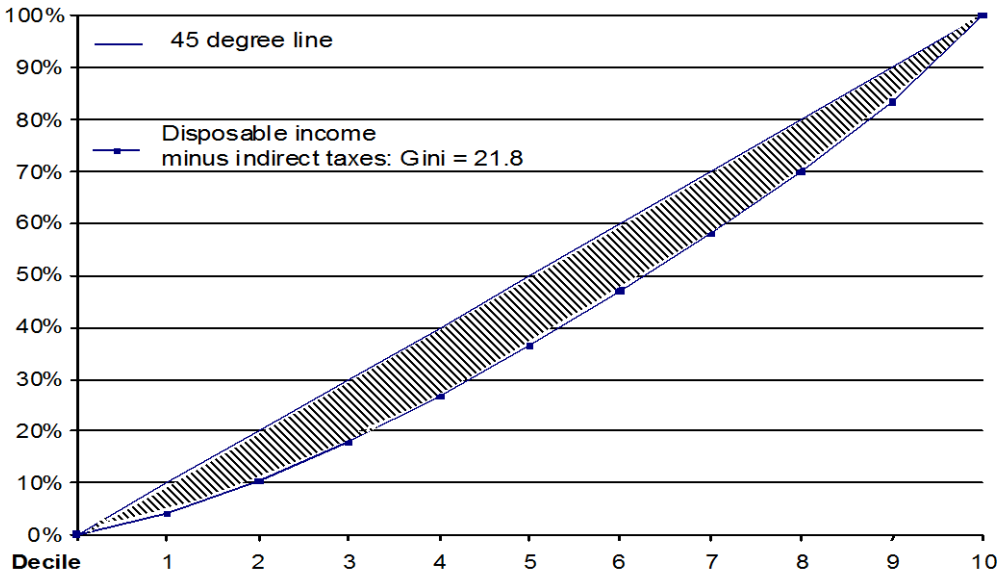


Figure 6 Accumulated income and Gini coefficients

Gini coefficients can be calculated based on the income data before or after taxes. In Figure 6 the Gini-coefficient after reducing income for direct taxes and indirect taxes is shown. Accumulated income (in %) at the vertical axes is given for the adults belonging to income deciles up to the income decile at the horizontal axes. The graph for this disposable income shows that 50% of the population (adults) receive around 36% of total disposable income after reduction for paid indirect taxes. The Gini coefficient is the patterned area in Figure 6 relative to the total area below the 45-degree line. The more equal the disposable income the less the Gini-coefficient will be.

To compare the effect of different environmental taxes and other indirect taxes we calculate changes in this Gini-cofficient as a result of a marginal change in total tax revenue. To make the changes comparable we examine the effect of collecting identical tax revenue (100 mill DKK) by using the different tax instruments one at a time.

The change in Gini coefficient is calculated by reducing the disposable income for each decile in Figure 6 with the tax payment corresponding to an additional tax revenue of 13.4 million Euro (100 mill. DKK). Each decile thus pays a proportional tax increase relative to their existing tax payment. For all the calculations the consumption pattern is assumed unchanged by the tax change. This is justified by the relatively small change in taxation and even less change in consumer price for the majority of taxes in question and due to lack of information about the demand response for the different income deciles.

The findings based on the income variable 'disposable income reduced for already existing indirect taxation' are presented in Figure 7. The change in total tax revenue is marginal (less than 0.2‰) and identical for all the calculations for the taxes included in the figure. However, the change in the specific environmental tax revenue is not marginal for all the taxes and there might therefore exist demand responses for a few taxes, that are not included in the calculation.

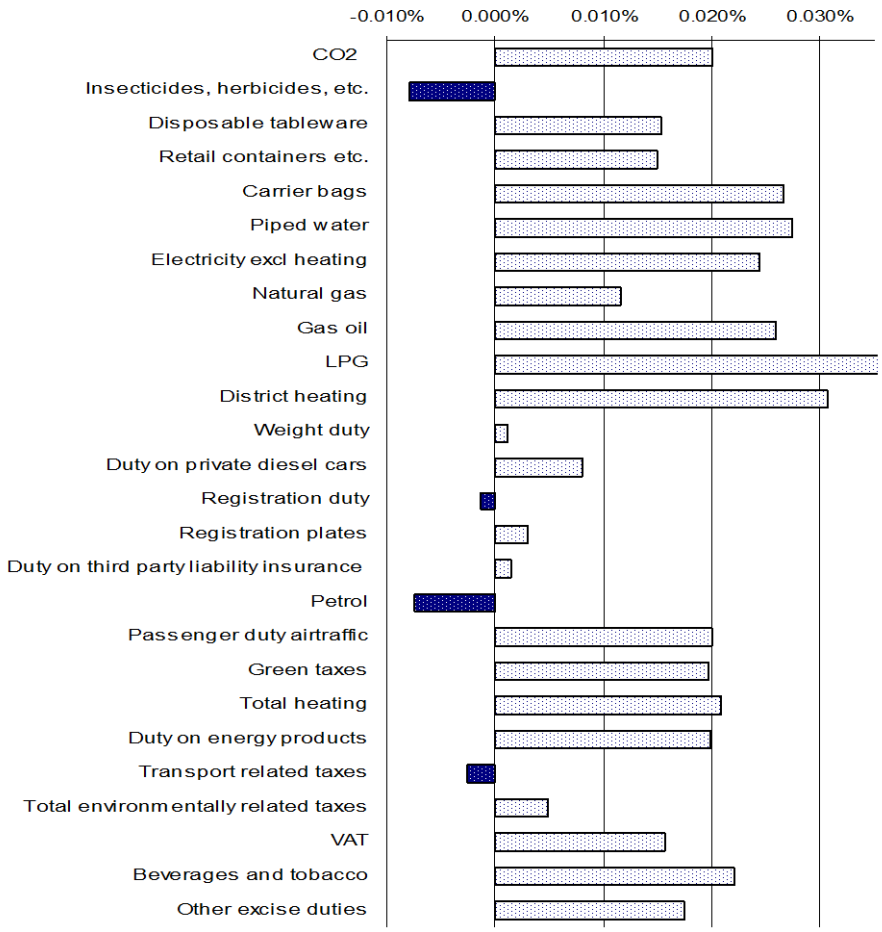


Figure 7 Change in Gini coefficient as a result of additional tax collection

The results in Figure 7 allow a comparison of the effect of collecting tax revenue from different environmental taxes. The figure identifies three of the environmental taxes as reducing inequality as measured by the Gini coefficient. The results regarding transport, as indicated in Figure 3, are reinforced by the calculated change in Gini coefficient, and the taxes reducing the coefficient within this category are identified as the tax on petrol and the

registration duty,[23] compared to the slightly positive effect of weight duty and annual duty on private diesel cars. Energy taxes and green taxes as aggregate categories are increasing inequality and have similar effect. They both increase the Gini coefficient slightly more than VAT, but less than duties on alcohol and tobacco. However, energy and environmental taxes exist that are considerably more biased towards the low-income groups than the average category. Taxes on piped water, district heating, carrier bags and especially LPG are all increasing inequality more than alcohol and tobacco taxes.

The results with regard to the ordering of individual tax impacts in Figure 7 is independent of which of the three income or expenditure variables is used. This can be observed in Appendix B, which lists results for the three different income variables. There is, however, a systematic difference in the redistribution effect for all taxes. All taxes are less problematic with respect to inequality if the expenditure variable is used instead of current disposable income, as most of the changes in Gini coefficients are lower with this variable.

7. POLICY IMPLICATIONS

For the discussion of environmental tax reform it is important to consider the general tendency for environmental taxes to be regressive as well as the different impacts of the various environmental taxes and duties. However, the average redistribution effect of green taxes and energy taxes is not much different from other consumption taxes (e.g. VAT).

Income tax reforms that are financed partly by increasing environmental taxes should also include lower income taxes for low-income groups.

Increased environmental taxes in combination with reduced marginal income tax rates could reduce total tax progressivity through both the income taxes and the environmental taxes, which would be an unattractive combination. For tax reforms to give a more balanced distributional effect there need to be reduced income taxes also for the low-income groups. Secondly, the increase in environmental taxes should include transport-related taxes.

Environmental tax reforms involving a change in the relative weight of different environmental taxes should focus both on the environmental and the distributional impact of the different tax categories.

Environmental tax reforms have distributional consequences and these should be evaluated based on the different environmental tax categories, since their distributional impact varies a great deal, as demonstrated by this study. The assumption that environmental taxes are only slightly regressive would be misleading if it is green taxes and especially taxes on water or retail containers, carrier bags, etc that are considered major parts of a tax reform. On the other hand, an environmental tax reform should not be rejected because of unattractive distributional impacts if it is based largely on higher taxes on private transport/vehicles or if the other parts of the tax reform are not too unbalanced with regard to distributional effects.

High taxes on private transport (registration duty and petrol) would be one way to balance the distributional impact of other environmental taxes with valid arguments concerning the high external cost of private transport (emissions - health, accidents, noise). However this would require that there are adequate public transport available so that the welfare loss associated with being excluded from owing your own car is not too great.

[23] The reason for the counter-intuitive result that petrol taxes are more regressive than the registration duty might be that people in higher income deciles live further away from their worksites than do lower income populations and therefore have higher daily driving needs.

The political pressure to reduce the high Danish registration duties and replace these with other taxes might have negative distributional impacts without improving the environment.[24] This study shows that both petrol taxes and registration duty are levied to a larger extent on high-income households. The registration duty ensures that the largest cars or the most luxurious cars, which also have the largest engines, are taxed more than the average family car. There might thus not be much environmental improvement from increasing the annual weight duty (green owner duty)[25] and reducing registration duty.

In most countries, except the poorest, consumption of electricity and water will be basic goods and therefore taxing these goods will harm the lowest income groups more than the high income groups. This implies that the widespread use of end-use taxation of electricity and the exemption of taxes for the fuels used for electricity production have less environmental effect and therefore also larger distributional effect than if taxes were levied on fuels.

The indirect effect through environmental taxes on domestic production might also have mixed distributional effects, as energy taxes associated with food production (with high energy content) would tend to be regressive, as would any energy taxes on public transport fuel consumption. In general the indirect effect would be close to the effect of VAT because the productive use of taxed input factors would be spread across most sectors.

One implication of our findings concerns the existing reduced tax rate for electric heating in Denmark.[26] There are no distributional arguments for maintaining the reduced tax rate, as this heating technology is today much more commonly found in houses owned by high-income groups than in older urban flats, where it used to be common.[27] The lost revenue would have a higher distributional impact if just used to reduce the ordinary electricity tax rate.

8. CONCLUDING REMARKS

Denmark levies a variety of environmentally related taxes on both households and producing sectors. However, the producing sectors have been exempted from many of these taxes, placing the majority of the direct tax burden on households. The green taxes were first introduced in 1992 and now constitute around 15% of the environmentally related taxes, and the degree of exemption is less for these taxes. In international comparison the environmental taxes, as a share of total tax revenues is not especially large, at least not if compared to other European countries. The specific characteristic of Danish tax composition is instead related to the high direct income taxation and lack of employer contribution to social security.

The distributional effects of environmental taxes in Denmark can be characterised by the following results.

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[24] The argument that a lower registration duty would reduce emissions by reducing average age of the car stock will not necessarily reduce fuel consumption and CO_2 emission, although other emissions might be reduced. The younger cars and lower emissions will be outweighed by larger and more cars probably resulting in higher petrol consumption and in the best case a slight reduction in emissions (excluding CO2).

[25] Green owner duty was introduced in 1997 to replace the weight duty for new vehicles. The duty is paid based on fuel consumption and emission categories, regardless of the annual use.

[26] The tax is around 0.9 Euro-cent/kWh less than the ordinary tax.

[27] A removal of the reduced rate would generate around 13.4 million Euro in additional tax revenue with a close to neutral distributional impact.

- Environmental taxes on average slightly increase after tax inequality if a current income measure is used but they reduce inequality if current expenditure is used
- The distributional effect varies a great deal between different environmental taxes, with transport-related taxes reducing after tax inequality and green taxes increasing inequality
- Residential location matters, as rural households are more exposed to environmental taxes because of transport requirements and less efficient heating technologies in combination with limited access to district heating and natural gas
- Environmentally related taxes on average are increasing inequality less than the VAT, whereas excise duties on alcohol and tobacco have more regressive effects than the VAT
- Using current expenditure instead of current income for the analysis produces more favourable results with respect to distributional impact, but the ranking of different taxes is not affected and the green taxes and energy taxes remains as taxes that increase inequality

The results from this study indicate that the environmental taxes in Denmark increase inequality except for transport-realated taxes, which is in line with the results from most other international studies. It must specifically be noted that in the Danish case many of the minor green taxes on piped water, carrier bags, etc., have even more negative distributional effects than the traditional energy taxes, especially electricity.

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REFERENCES

Bovenberg, A. L. (1998) Environmental Taxes and the Double Dividend. *Empirica* **25**, p. 15-35.

Bovenberg, A. L., and van der Ploeg, F. (1998) Consequences of Environmental Tax Reform for Unemployment and Welfare. *Environmental and Resource Economics* **12** (2), 137-.

Bovenberg, A. L. (1999) Green Tax Reforms and the Double Dividend: An Updated Readers Guide. *International Tax and Public Finance* **6**, 421-443.

Cornwell, A., and Creedy, J. (1996) Carbon Taxation, Prices and Inequality in Australia. *Fiscal Studies* **17** (3), p. 21-38.

Cornwell, A., and Creedy, J. (1998) Measuring the Welfare Effects of Tax Changes. *Empirical Economics* **22** (4), p. 589-613.

Ekins, P. (1999) European Environmental Taxes and Charges: Recent Experience, Issues and Trends *Ecological Economics* **3** (1), p. 39-62.

Hamilton, K., and Cameron, G. (1994) Simulating the Distributional Effects of a Canadian Carbon Tax. *Canadian Public Policy* **20** (4), p. 385-399.

Jørgensen, S., and Pedersen, T. B. (2000) Danish Income Distribution and Net Contribution to Public Finances. *6th Nordic Seminar on Micro Simulation Models,* http://www.oem.dk/seminar/jorgensen_Pedersen.pdf

Klinge Jacobsen, H; Birr-Pedersen, K; Wier, M. (2001) Fordelingsvirkninger af energi- og miljøafgifter, Risø-R-1297(DA)

Labandeira, X., and Labega, J. (1999) Combining Input-Output Analysis and Micro Simulation. *Fiscal Studies* **20** (3), p. 305-320.

Metcalf, G. E. (1998) A Distributional Analysis of an Environmental Tax Shift, NBER Working Paper 6546, (also published) *National Tax Journal* **52** (4), (1999), p. 655-681.

Ministry of Economic Affairs (2000) The Law Model: Microsimulation Models http://www.oem.dk/pub/lovpamflet00/_samletUK.pdf

OECD (1994) (Harrison, D.) The Distributive Effects of Economic Instruments for Environmental policy, Paris OECD.

OECD (1995) (Harrison, D.) Climate Change, Economic Instruments and Income Distribution, Paris OECD.

Pearson, M., and Smith, S. (1991) The European Carbon Tax: An Assessment of the European Commission's Proposals, Institute for Fiscal Studies, London.

Pirttila, J., and Tuomala , M. (1997) Income Tax, Commodity Tax and Environmental Policy. *International Tax and Public Finance*, **4**, p. 379-393.

Poterba, J. M. (1991a) Tax Policy to Combat Global Warming: On Designing a Carbon Tax. In R. Dornbusch and J. M. Poterba (eds), *Global Warming: Economic Policy Responses to Global Warming*. Cambridge, Mass, MIT Press.

Poterba, J. M. (1991b) Is the Gasoline Tax Regressive. In: *Tax Policy and the Economy,* Volume 5 Cambridge, Mass, National Bureau of Economic Research, p. 145-164.

Smith, S. (1992) Taxation and the Environment: A Survey. *Fiscal Studies* **13**, p. 21-57.

Smith, S. (1995) Green Taxes and Charges: Policy and Practice in Britain and Germany. Institute for Fiscal Studies, London.

Speck, S. (1999) Energy and Carbon Taxes and their Distributional Implications. *Energy Policy* **27**, p. 659-667.

Statistics Denmark (1998) Skatter og afgifter 1998, Statistics Denmark, Copenhagen.

Statistics Denmark (1999) Consumption Survey – Methodology: From Data Collection to Publishing, (in Danish), Statistics Denmark, Copenhagen.

Symons, E. J., Proops, J., and Gay, P. (1994) Carbon Taxes, Consumer Demand and Carbon Dioxide Emissions: A Simulation Analysis for the UK. *Fiscal Studies* **15** (2), p. 19-43.

Symons E.J., Speck S., and Proops J. L. R. (1997) The Distributional Effects of European Pollution and Energy Taxes. In: Conference Proceedings *The International Energy Experience: Markets, Regulation and Environment* . Warwick, UK, December 1997.

Walls, M., and Hanson, J. (1999) Distributional Aspects of an Environmental Tax Shift: the Case of Motor Vehicle Emissions Taxes. *National Tax Journal* **52** (1), p. 53-65.

Wier, M., Birr-Pedersen, K., and Klinge Jacobsen, H. (2001) Distributional Effects of CO2 Taxes: Accounting for the Indirect Effects (Working Paper).

Appendix A

Income decile	Ave-rage	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
FU: Disposable income Euro	16874	7036	9508	11611	13619	15335	16821	18525	20713	23781	33956
FM: Disposable income Euro	16335	6569	10380	12343	14142	15857	17250	18408	19642	21337	27418
ØM: Disposable income Euro	16223	8048	10603	12201	13509	14765	16028	17401	19046	21342	29285
FU: Available funds per household Euro	30742	15840	15785	21038	27176	30893	33844	35652	39313	41424	53252
FU: Consumption per household Euro	28037	20027	16270	21064	25884	28973	30174	32528	33749	34927	42504
FU: Consumption per adult Euro	17096	13717	13121	13767	15226	16747	16579	17971	19175	19404	23879
FM: Adjusted consumption per adult Euro	15545	12021	13050	13821	14511	15565	15880	16908	17292	17763	18638
FU: Adults[28]	4750	369	418	441	425	431	466	505	537	583	575
FM: Adults	138461	13846	13846	13846	13846	13846	13846	13846	13846	13846	13847
ØM: Adults	409065	40906	40907	40906	40907	40906	40907	40906	40907	40906	40907
FU: Adults per household	1.64	1.46	1.24	1.53	1.7	1.73	1.82	1.81	1.76	1.8	1.78
ØM: Adults per household	1.66	1.50	1.52	1.51	1.61	1.73	1.79	1.85	1.89	1.88	1.82
FU: Children per household	0.48	0.63	0.21	0.49	0.69	0.87	0.7	0.56	0.43	0.26	0.23

FU: ForbrugsUndersøgelse (Household Expenditure Survey), FM: FinansMinisterietv(Ministry of Finance), ØM: ØkonomiMinisteriet (Ministry for Economic Affairs.)

[28] The Danish expenditure survey has made a distribution of the sample on income deciles based on individuals and not adults, as in the data from the ministries. As the expenditure survey is not completely representative for the entire population, the adjustment results in a varying number of people in each decile. The number of adults is given here.

Appendix B: Changes in Gini coefficients based on different income variables

Tax	Disposable income minus indirect taxes	Disposable income	Expenditure	Revenue from house-holds 1997 (millions Euro
CO_2 tax	0.021%	0.015%	0.007%	256
Pesticides	-0.008%	-0.010%	-0.094%	10
Disposable tableware	0.015%	0.011%	-0.010%	1
Retail containers, etc.	0.015%	0.010%	-0.011%	109
Carrier bags, etc.	0.027%	0.021%	0.031%	15
Piped water	0.027%	0.021%	0.033%	156
Green taxes	0.020%	0.015%	0.006%	554
Electricity and water	0.021%	0.016%	0.010%	748
Electricity excl. heating	0.024%	0.019%	0.023%	492
Electric heating	0.011%	0.007%	-0.027%	53
Coal	0.023%	0.018%	0.019%	1
Natural gas[29]	0.012%	0.007%	-0.024%	1
Oil products in total	0.019%	0.014%	0.002%	333
Gas oil, etc.	0.026%	0.020%	0.028%	244
LPG	0.042%	0.034%	0.085%	7
District heat[30]	0.031%	0.024%	0.045%	0
Heating in total	0.021%	0.016%	0.010%	374
Energy taxes in total	0.020%	0.015%	0.006%	927
Weight duty	0.001%	-0.002%	-0.061%	544
Annual diesel car duty	0.008%	0.004%	-0.036%	14
Registration duty	-0.001%	-0.004%	-0.070%	1509
License plates	0.003%	0.000%	-0.054%	44
Third party liability insurance	0.002%	-0.001%	-0.060%	102
Petrol	-0.007%	-0.009%	-0.092%	980
Air passenger tax	0.020%	0.015%	0.007%	4
Transport-related taxes in total	-0.003%	-0.005%	-0.074%	3198
Environmentally related taxes and duties in total	0.005%	0.002%	-0.048%	4678
VAT	0.016%	0.011%	-0.009%	9034
Alcohol and tobacco	0.022%	0.017%	0.014%	1526
Other excise duties	0.017%	0.013%	-0.002%	1247

[29] Calculated based on the tax rate for 2000 and based on (heating) energy consumption data supplied from the Ministry of Economic Affairs.

[30] The assumption is that half of the revenue from this tax on heat produced at incineration plants is distributed on the entire district heat consumption even though the tax is not applied to all district heat consumption.