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Environmental taxation and distributional consequences

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Abstract

Denmark today carries one of the heaviest environmental tax burdens in the world, bringing in around ten percent of public revenues. While evaluations have shown positive effects of the Danish CO₂- and other environmental taxes, a considerable barrier for an increased use of these instruments today, seems to be a widespread perception of their socially adverse effects. The aim of the present paper is to further examine the direct and indirect distributional consequences of Danish CO₂-taxes on industry and households, based on actual tax payments, directly and indirectly paid by households. Thus, we will evaluate the CO₂-tax burden for households in different income brackets, in order to examine whether CO₂-taxes tend to be progressive or regressive. In this paper, it is demonstrated, that CO₂ taxes imposed on energy consumption in households, as well as in industry, does in fact tend to be regressive, and therefore to have undesirable distributional effects. This holds especially for taxes imposed directly on households. To analyze this, we apply national consumer survey statistics in combination with input-output tables and energy consumption data. The present study distinguishes itself by being based on empirical observations of already implemented taxes, whereby behavioural responses and technological change to the taxes will be reflected in actual tax payments. Furthermore, the study considers urbanity, in order to find out, if rural households suffer from a higher CO₂-tax burden.

1. Introduction

In an effort to fulfil an ambitious national reduction target to reduce emissions of greenhouse gases, Denmark was the first country to impose explicit CO₂-taxes on both household and business energy consumption in 1992/93. As an effect of the 'green' reform of the Danish tax system during the 1990s, which has gradually shifted some of the burden of taxation away from incomes towards natural resources, Denmark today carries one of the heaviest environmental tax burdens in the world, bringing in around ten percent of public revenues.

With one of the highest national CO₂ emission levels in Europe, the need to adopt ambitious national climate policies and measures was readily accepted by a broad majority in the Danish Parliament in the late 1980s. In an ambitious 1990 energy action programme, the Danish Government proclaimed a national target of reducing CO₂ emissions by 20% by the year 2005 in relation to 1988 levels. Later, Denmark has taken upon itself a new national target of reducing emissions by 21 % of 1990 levels between 2008-2012, as it's share of the common European Union Kyoto commitment to reduce greenhouse gas emissions by 8 % of 1990 levels between 2008-2012. In an effort to fulfil its ambitious international climate commitment, Denmark was the first country to impose explicit CO₂-taxes on both household and business energy consumption in 1992/93. Although the effective CO₂-tax level on business energy consumption was initially very low, it was later raised considerably when an overall package of business energy efficiency measures was introduced in 1995. Since then, Danish companies have carried the world's highest net CO₂-tax burden.

It has been shown that CO₂-taxation works as an effective measure to reduce Danish household and business CO₂-emissions (Andersen et al. [1]; Bjørner [2]; Danish Ministry of Finance [3]). A considerable political barrier to an increased use of CO₂-taxation however, seems to be a widespread perception of its socially adverse effects (European Environmental Agency [4], [5]). This perception has been substantiated by various studies that find that CO₂-taxes tend to increase tax regressivity (Pearson [6]; Hamilton [7]; Barker et al. [8]). Apparently regressivity not only increases with CO₂-taxes paid directly by households, but also with CO₂-taxes imposed on industry (in this paper termed, *indirect household CO₂-taxes*) (Cornwell [9], [10]; Symons et al. [11], [12]; Hamilton [7]; Labandeira [13]; Rapanos [14]).

The aim of this study is to further examine the direct and indirect distributional consequences of Danish CO₂-taxes on industry and households, based on actual tax payments, directly and indirectly paid by households. Thus, we will evaluate the CO₂-tax burden on households in different income brackets, in order to examine whether CO₂-taxes tend to be progressive or regressive. The present study distinguishes itself by being based on empirical observations of already implemented taxes, where behavioural responses and technological change resulting from the taxes will be reflected in actual tax payments. Furthermore, the study considers urbanity, in order to find out, whether rural households suffer from a higher CO₂-tax burden. Previous studies of Danish households (Wier et al. [15]) found that rural households have higher energy consumption due to higher transport and heating needs.

Some other studies have also evaluated the effects of CO₂ taxes on energy consumption based on empirical data, but until now, there have been few empirical studies on their distributional effects. One of these studies, by Dubin and Henson (Dubin [16]), examined the distributional effects of energy taxes using US national data from 1979, confirming that energy taxes are regressive.

2. The Danish CO₂ tax

The household CO₂ tax plus the household energy tax rates amount to an effective tax level of DKK 600 per ton of CO₂. The social disparities of indirect environmental taxation on lower income groups were compensated through the reduction of taxes on low-incomes and an increase in child support.

The business tax scheme includes a CO₂ standard tax rate of DKK100 per ton CO₂. Except for energy used for space heating, all energy-intensive industries are entitled to a considerable reduction in the CO₂ tax in return for entering into voluntary agreements on energy efficiency with the Danish Energy Agency. In Bjørner and Jensen (Bjørner [2]) it is concluded that the voluntary energy efficiency agreements have led to a reduction in energy consumption of 9% in those industries. Another ex-post study (Pedersen et al. [17]), based on data from 1996 to 1997, estimated that the voluntary agreements had lowered emissions by 5%. This is quite interesting, as the results suggest that voluntary agreements may in fact be as effective as taxes in reducing CO₂ emissions.

3. Data and Methods

To evaluate the indirect effect on households, of business CO₂ taxes we use a static input-output model, which we extend with a tax matrix. Following the tradition of Duchin [18], Lenzen [19], Biesiot & Noorman [20], Weber & Perrels [21], and Wier et al. [15], we combine input-output analysis with information on household characteristics. Thus, in the model, direct and indirect household tax payments are given for various household types, grouped according to income bracket and urbanity.

The national input-output system is used to calculate the actual indirect tax payments by households for different types of commodities based on the actual tax payments by industries. In earlier theoretical studies these indirect tax payments were approximated by first calculating indirect CO₂ intensities of different commodities using the input-output system and then applying an indirect CO₂ tax per ton CO₂ (Symons et al. [11], Labandeira [13] and Cornwell [10]). This approach assumes that levies imposed on the industry are fully transmitted into final commodity prices. Thus, those households that demand an industry's commodities will eventually pay the CO₂-taxes first paid by industry (indirect household tax payments). We will follow this approach, recognizing, however, that the degree of transmission will depend on technological development and substitution possibilities in industries as well as in households.

All data used in this study are compatible, as they apply identical classifications of goods and activities, making it possible to utilize the data in an integrated model. The data used for the present analysis are:

- Danish *input-output tables* for the year 1996 from Statistics Denmark, (tables documented in Statistics Denmark [22]). These tables comprise 130 production sectors and 9 categories of final demand. One of the latter is private consumption, which is divided into 72 components, 5 of which are direct energy consumption by households.
- *Tax vector* for the year 1996 (special service from Statistics Denmark) containing CO₂ tax payments from 130 production sectors.

- The *consumer survey* from Statistics Denmark (Statistics Denmark [23]). The survey comprises the consumption of 1334 commodities by 3438 representatively selected households. The survey data applied in the present study are based on data from 1996. Various characteristics of the households are registered e.g. number and age of children and adults, type of accommodation, urbanity, socio-economic status, education and type and level of disposable household income and expenditure. 390 family types can be distinguished. Data are collected through registration of household purchases on a daily basis, supplemented by personal interviews and information from the registrars. The respondent rate is 68.5%. As a final step in the calculation procedure, the data are adjusted for the proportion of non-respondents, in order to give each household type the appropriate weight.

4. Results

4.1 The direct and indirect household CO₂ tax payments

In 1996, the direct household tax payment was DKK 1.88 billion. The indirect household payment (taxes paid by industry, but fully transmitted in final consumer prices) was 0.56 billion - approximately one third of direct household payments.

Table 1: Indirect CO₂ tax payments per commodity: Top 5 and Bottom 5, 1996

Number on list	Commodity	Tax payment <i>Per Cent</i>
Top 5		
1	Water supply and sewerage services	0.39
2	Package holidays	0.38
3	Dairy products	0.26
4	Refuse collection and treatment	0.22
5	Butter and oils	0.22
Bottom 5		
5	Insurance services	0.07
4	Purchase of vehicles	0.04
3	Cigarettes and tobacco	0.04
2	Domestic services	0.04
1	Gross rent	0.03

Looking at tax payments across commodities, large variations are revealed. Direct household tax payments are associated with energy commodities, and these payments are much higher than indirect tax payment per DKK1000 consumed, simply because of the high CO₂ content in these commodities.

Electricity is the most heavily taxed energy type (83 DKK per 1000 DKK consumed), second is oil (60 DKK per 1000 DKK consumed) and third is gas (43 DKK per 1000 DKK consumed).

Turning to indirect household CO₂ tax payments, Table 1 lists the five commodities with the highest and the five commodities with lowest tax payments in 1996 as a percentage of total household consumption of the commodity. As can be seen in Table 1, the commodities with the highest indirect CO₂ tax liabilities are water, travel, and various types of food. In contrast, the five commodities with the smallest CO₂ tax rates are mainly services and financial transfers.

The large variation in CO₂ tax payments indicates that different household types, having different lifestyles and consumption patterns, are likely to differ significantly with regard to CO₂ tax payments. This is examined in the following.

4.2 Distributional effects of the CO₂ tax

The distributional impact of environmental taxes can be examined by looking at tax payments relative to annual disposable income for the deciles. As income rises, a falling share going to environmental taxes indicates a regressive tax. Figure 1 shows CO₂ tax payments broken down on income deciles. The regressivity in tax payments is obvious; direct as well as indirect tax payments increase with income, but constitute a smaller and smaller share of disposable household income.

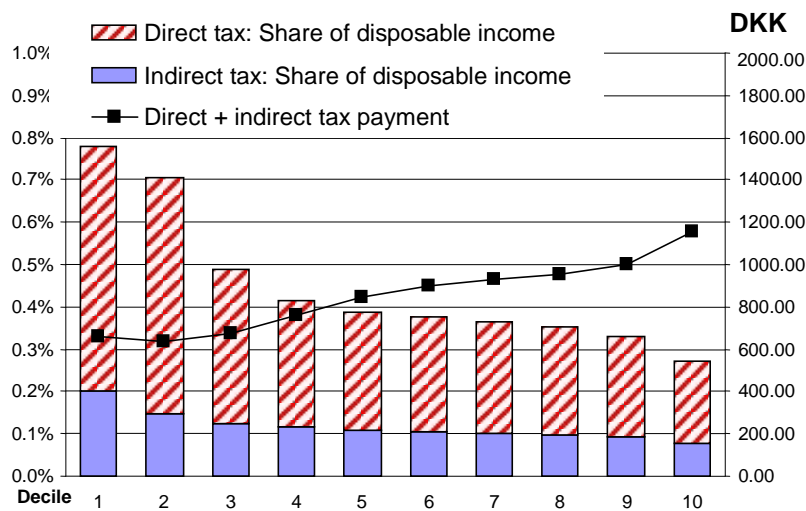


Figure 1: Direct and indirect household tax payments (DKK) by income deciles, 1996

In 1996 the average household paid around DKK599 in direct and DKK225 in indirect CO₂ taxes per year. Low income households (1st decile, i.e. bottom 10 percent of income units) paid 25 per cent less direct and indirect CO₂ taxes in 1996, compared to the average Danish family. High income households (10th decile, i.e. top 10 per cent of income units) paid 40 per cent more direct and indirect CO₂ taxes in 1996, compared to the average Danish family. In spite of these differences, however, low income families paid (direct as well as indirect) CO₂ taxes constituting around 0.8 per cent of disposable household income, while high income families paid CO₂ taxes constituting around 0.3 per cent of disposable household income.

4.3 Measuring inequality

To assess the regressivity of a tax system, it is useful to apply the Gini coefficients, which are defined by the proportion of the area under the diagonal that lies between the diagonal and the Lorenz curve, which relates the cumulative percentage of aggregate costs to the cumulative percentage of the population paying those costs, cf. Dorfman [24]. In the present study we consider the marginal Gini coefficients, which we define as the change in the Gini coefficient after collecting an additional DKK100 million in taxes (following the method applied by Jørgensen [25]). Positive changes indicate regressive tax burden, and vice versa. Table 2 shows the marginal Gini coefficients for direct CO₂, indirect CO₂, and total CO₂ taxes in 1996. Furthermore, the average marginal Gini coefficient for all other Danish levies on commodities are shown. As appears from the Figure, the CO₂ taxes are more regressive than the average Danish levy, and direct CO₂ taxes are more regressive than the indirect CO₂ taxes. Furthermore, VAT taxes are less regressive than the CO₂ tax, and petrol taxes are in fact progressive.

Table 2: Marginal Gini coefficients, 1996

Type of levy	Marginal Gini coefficient (%)
Direct CO ₂	0.021
Indirect CO ₂	0.015
Direct and indirect CO ₂	0.019
Petrol	-0.007
VAT	0.016
All types of levies	0.013

4.4 The importance of urbanity

There are considerable differences in direct energy consumption between rural and urban households in Denmark, as transportation and heating needs are much higher for families living in rural areas. Indirect energy consumption does not vary significantly with urbanity (Wier et al. [15]). Figure 2 shows direct and indirect CO₂ tax payments relative to disposable income for families in rural and urban areas. As can be seen from the figure, direct CO₂ tax payments constitute a

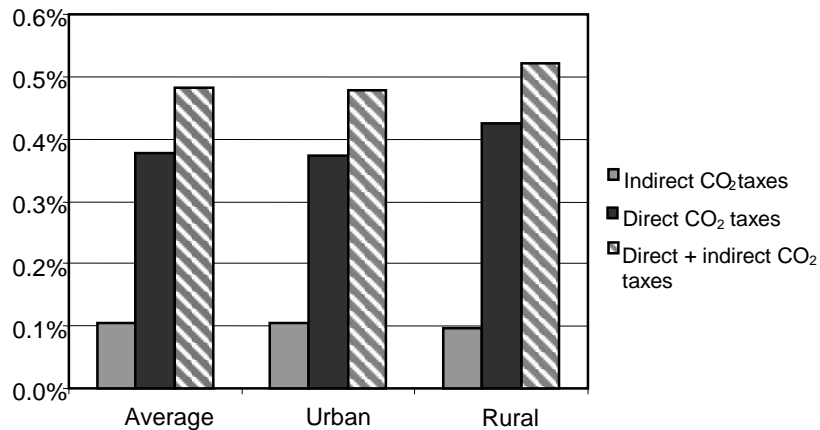


Figure 2: Urban and rural CO₂ tax payments as a share of disposable income, 1996

higher share of disposable income for families living in rural areas due to their higher direct energy requirements. For indirect CO₂ tax payments, the opposite holds: CO₂ tax payments constitute a slightly lower share of disposable income for families living in rural areas. Hence, there is only a small difference in total CO₂ tax payments between families living in rural and urban areas of 0.04 percentage points.

The differences in direct as well as in indirect CO₂ tax payments are due to underlying differences in consumption patterns. Tax payments from consumption of food, clothing and housing are similar for families living in urban and rural areas. In contrast, significant differences are observed for the purchase of vehicles, which is higher for rural families and consumption of purchased transport, leisure activities and travel, which is higher for urban families. Correspondingly, looking at direct CO₂ tax payments, rural families have higher tax payments, primarily due to higher consumption of heating and electricity.

5. Conclusions and policy implications

Our study demonstrates that Danish CO₂ taxes are regressive, and this result holds for direct as well as indirect CO₂ tax payments. While both types of CO₂ tax payments are increasing with disposable household income, they constitute a still smaller share of the budget as income increases. The CO₂ taxes are more regressive than the average Danish levy, including VAT taxes, and direct CO₂ taxes are more regressive than the indirect CO₂ taxes. Our results also suggest that only minor inequality exists between households that differ with respect to urbanity, however.

Taxing CO₂ emissions is an often debated and recommended policy instrument to combat climate change. In several countries “green” tax reforms have been introduced, and in many countries, similar reforms are proposed, as a mean to reduce the environmental load of modern society (Schlegelmilch [26];

European Environmental Agency [5]). Nevertheless, as demonstrated in this paper, CO₂ taxes imposed on energy consumption in households and industry tend to be regressive, thus often having undesirable distributional effects. This result also holds for most other green taxes imposed on Danish households, cf. Jacobsen and Wier (Jacobsen [27]).

As most green taxes appear to be regressive, governments might have to ensure that sufficient compensation measures are in place to reduce the burdens on low income households. In order to secure the social acceptability of environmental tax regimes it seems somewhat essential to supplement green taxes with compensatory measures that outweigh the distributional effects if such policies are to be widely introduced in other countries in the coming years. Such measures might be introduced directly as part of the green tax regime, e.g. by the introduction of special green allowances, or indirectly through the reduction of other types of taxation.

Since direct CO₂ taxes are more regressive than indirect CO₂ taxes, another way to reduce regressivity is to shift the tax burden from taxes imposed on households to taxes imposed on business. Such changes in the CO₂ tax scheme might be implemented in conjunction with measures to secure international competitiveness. Several studies, however, (Baranzini et al. [28], Barker [29], Ekins [30], Ekins [31], Porter [32]) suggest that the competitiveness losses are small. Furthermore, if the CO₂ tax scheme applies voluntary agreements for energy intensive industries, possible losses of competitiveness are avoided and empirical results suggest that voluntary agreements may in fact be as effective as taxes in reducing CO₂ emissions, cf. Bjørner and Jensen (Bjørner [2]), Pedersen et al. (Pedersen et al. [17]),

Some countries have tried to build progressivity directly into the green tax systems. A progressive scale for charging households for water consumption and waste water treatment is e.g. currently being used in Portugal. Likewise, in The Netherlands, tax free lower income brackets have been introduced successfully (European Environmental Agency [4]).

In Denmark, the administrative costs expected from maintaining progressivity directly in the green tax systems themselves have been seen as too high (Danish Ministry of Taxation [33]). Policymakers have instead chosen to compensate the socially adverse effects of green taxation through reductions in other types of taxation. While this solution might have been more cost-effective, it will also have its limitations. First, its effective application is probably, to some extent, dependent on existing tax structures, making it somewhat easier to apply in countries like Denmark, where general tax levels are high and there is a broad array of applied tax bases to choose from, when taking compensatory measures. In countries with lower tax levels and less applied tax bases to choose from, it might be more expedient to build social compensation measures directly into the structure of the new environmental tax regimes. Second, the solution can prove weak over time, as people will have a tendency to forget how they were compensated years back from the socially adverse effects of a current environmental tax regime. The perception of environmental taxation as socially adverse might in this way rise over time if the compensatory measures cannot be pointed out clearly as an integral part of the environmental tax regime itself.

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