Regional energy consumption and income differences in Denmark

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Abstract

Internationally a debate on the distributional impact of energy taxation has focused on the tax burden relative to income. The general conclusion is that taxes are regressive, but at a varying degree for different countries. This paper deals with energy consumption and tax impacts in a regional comparison in addition to the income perspective.

Energy consumption varies a great deal depending on the area of location of households. This study examines the relationship between location, income, heating technology characteristics, and the energy tax that the households pay. The paper aims at identifying general implications of energy taxes with respect to different impacts on population groups depending on location and income. Tax payments associated with energy use are considered relative to total disposable income of households grouped in income deciles and by other characteristics.

The importance of energy consumption and tax payments depends on the income levels in rural areas compared to income in urban areas. In Denmark, the income difference is quite small, but energy consumption, and therefore also the burden of energy taxation, is higher in rural areas. Furthermore the low-income households in rural areas consume much more energy than low-income households in urban areas. Low-income households in rural areas are therefore a group that is specifically exposed to increased energy taxation.

The households living in rural areas have the disadvantage of not having access to the public heating grids and the natural gas grids. Therefore they have to rely on individual solutions, which to a large extent are gas oil, electricity, and biomass. Apart from higher energy costs, the rural households also pay considerably higher taxes on transport by private cars. This is caused by the less developed public transport in rural areas and therefore higher car frequency in combination with the more sparse population.

This paper documents that the rural population has higher energy bills also compared to income, but there is not income inequality between rural and urban areas in Denmark. In countries with higher inequality in income distribution and a higher proportion of low-income households in rural areas, the impact of energy and transport taxes might be more uneven. For countries with a high proportion of low-income households living in urban areas and little income inequality this issue might, as in the Danish case, not be a problem for the design of energy and environmental taxes.

***Keywords**: Energy consumption, regional income, energy tax, distribution*

1. Introduction

Different regional income levels, as well as income variations in general, have always been a major concern for policy makers. There exist differences in energy consumption that are

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correspondingly important for energy policy. Regional differences in energy consumption of households are important for energy policy, and especially for the implementation and structure of energy and environmental taxes. The issue of distributional consequences has most often been considered in relation to income groups in specific countries. The impact on different groups of households depending on the regional localisation has been considered less, but for energy consumption this difference might be quite important. Rural households[1] have different heating options, less network availability, and finally they are located more disperse resulting in higher needs for private transport.

Studies concerning environmental taxation and distributional impacts in general have found that these taxes have regressive effects. The gradual increase in energy and environmental taxation has raised concern over the distributional impacts of such taxes[2]. The OECD (1994, 1995) examined distributional effects of environmental policy in a broad context, including both theoretical results and empirical findings on distributional effects caused both by the taxation and by a reduction of environmental pressure. Empirical findings[3] 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 due to the climate-induced necessity for heating in northern Europe. The importance of heating needs and technology again points to implications for tax impact on rural households relative to urban households. This study therefore explores the regional impact further.

Taxes related to motor vehicles have been 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. This analysis therefore also considers transport-related taxes for the rural population relative to the average population.

Of course, the distributional impact of taxes should be considered relative to the environmental damage associated with energy consumption. This issue is also discussed here, but no attempt has been made to include estimates of damage compared with the tax payment of individual groups. This has not been part of the study and furthermore to have different estimates of damage from different regional energy consumption would involve a very comprehensive study if, indeed, it were practical at all.

With respect to the relevance to other countries of the findings reported here for Denmark, the different level of energy consumption and the composition between rural and urban areas makes the findings relevant for many developed countries with a similar energy structure, and for policy considerations regarding uniform or varying energy tax rates. In many countries with more income variation than Denmark, the regressivity and the regional difference in tax burden could be even more pronounced than in the Danish case.

For policy implications, in a final section the paper examines not only the present Danish energy tax structure, but also compares this to a situation with a more uniform energy tax system.

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[1] 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.

[2] See Ekins (1999) for an overview of the different taxes and charges implemented in Europe.

[3] 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.

2. Income distribution in Denmark

The analysis below is based on a large amount of empirical material for energy consumption in 246,000 households in combination with corresponding socio-economic data drawn from governmental registries. For a description of the data and its use, see Ministry of Economic Affairs (2000). All adult persons in the sample are divided into income deciles based on the disposable income of their households[4]. In order to take into account different household sizes, the aggregate income of the household is first adjusted to account for the age groups in the household[5]. The adjusted income is then divided by the number of adults in the household. Deciles for regional categories are based on the distribution of deciles for the entire sample[6].

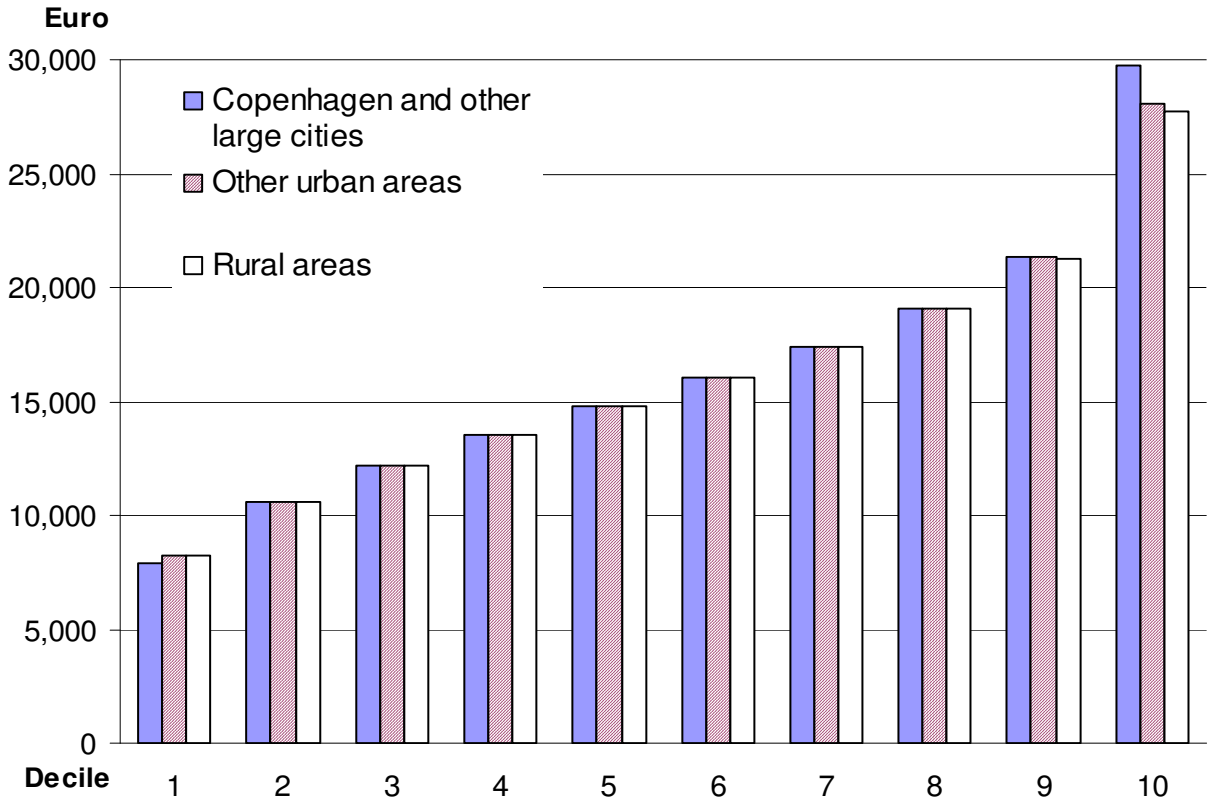

Figure 1 Disposable income per adult in income deciles 1997

Distribution of income is relatively equal in Denmark. The progressive tax system as well as relatively little variation in pre-tax incomes in combination with public transfers result in

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

[5] 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.

[6] Therefore the number of rural adults in each decile is not equal. The number of rural adults in the lowest income decile is e.g. a little higher than 1/10 of the rural adults.

the disposable income variation in Figure 1. Average income per adult is a little less in rural areas compared to income in Copenhagen. The main observation is, however, that income variation is greater in urban areas than in rural areas[7]. Thus, on average, the rural population seems to be just as well off as their urban counterparts, which is in contrast to what might be expected based on differences in official salaries in the two areas and an anticipated lack of modernisation and high salary jobs in rural areas. Additionally the general price level in rural areas is lower for agricultural products (own supply) and for many services (lower wage levels). In particular, the cost of housing is considerably lower than in cities and suburbs. Therefore the purchasing power of rural households might be even higher than in urban areas.

The difference in disposable income between the 1st and the 10th deciles is around 1 to 3, which is not matched by a correspondingly higher energy consumption and tax payments for the 10th decile. The energy tax profile for the income deciles is shown below in Figure 6.

3. Energy consumption in different regions in Denmark

From the small difference in income levels between the regional groups seen in Figure 1 we now move to energy consumption in the regions. Figure 2 show that there is a much larger difference in energy consumption both with respect to the level and the composition of fuels/technology. Energy consumption is considerably higher in rural areas and in other urban areas compared to Copenhagen and other major cities. The main explanation for this is the composition of housing. Copenhagen has a large proportion of apartments, with average size much smaller than detached houses that dominate the type of dwelling in the two other areas. This is observed from Figure 3 that shows about the same level of energy consumption for detached houses regardless of where these are located.

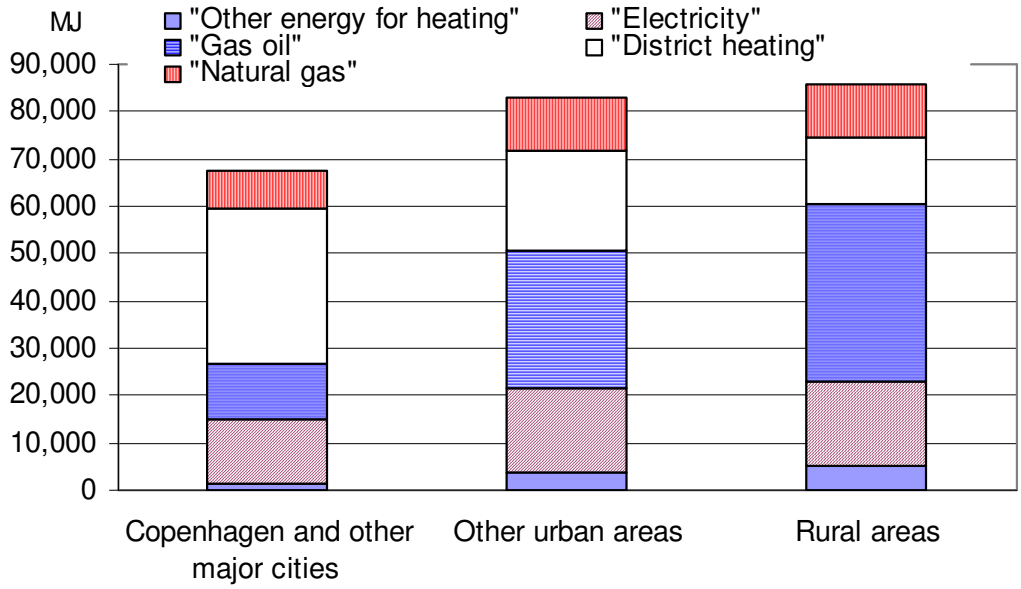

Figure 2 Consumption of electricity and energy for heating in households 1997

However, Figure 2 also reveals that there is a difference in the composition of energy consumption. Rural areas have relatively more gas-oil-based heating and less district heating

[7] Mainly that those in rural areas belonging to the highest income decile have less income than the highest income decile in Copenhagen.

as compared to the two other areas. Secondly consumption of other fuels is slightly higher, representing more electric heating and more biomass (straw). The first difference is a result of less coverage of supply grids and contributes to the current energy taxation being less favourable to rural households. The second difference for electric heating is also unfavourable for rural households, but a large proportion of electrically heated houses in rural areas have additional heating devices such as wood stoves. The availability of straw on farms also provides a relatively cheap access to untaxed fuels on farms that reduces the energy tax payment for these households considerably. However, usually the farms that produce their own straw are also relatively wealthy households farms produce their own straw.

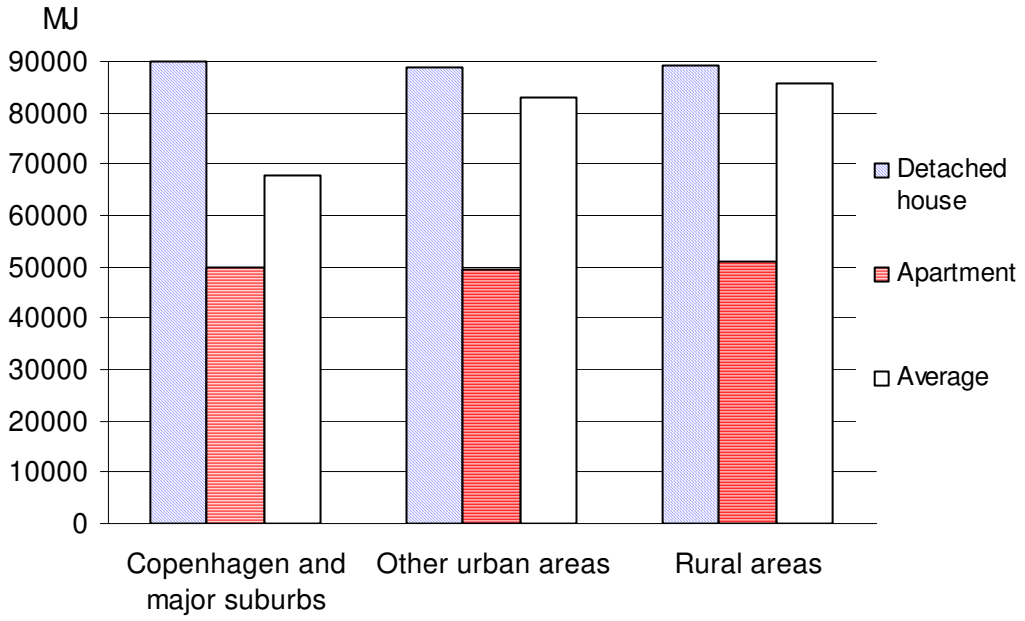

Figure 3 Energy consumption depending on location and type of dwelling

The minor role of apartments in rural areas means that the average energy consumption in rural households is close to the level of consumption for households in detached houses. Rural households do not consume more energy than their urban counterparts if considered separately for each category of dwellings. However, the income for urban households in detached houses is well above that of rural households living in detached houses.

4. Energy taxes and household income

The figures for disposable incomes in Figure 1 are averages for the regions. The disposable income for households living in detached houses is somewhat lower in rural areas compared to urban areas (EUR 15,330 against EUR 17,997)[8]. Therefore the burden of a uniform energy tax relative to disposable income seems to be higher in rural areas. This is for a tax based entirely on energy consumption, but energy taxation in Denmark is not proportional to total energy consumption. Therefore the composition of energy taxation in the different household groups is important for their tax payments. Energy taxation of the households in Figure 4 does not just reflect the difference in energy consumption seen in Figure 2, but to an even larger extent the different tax rates.

[8] The lower incomes in urban households living in apartments lead to similar average incomes in the two regions.

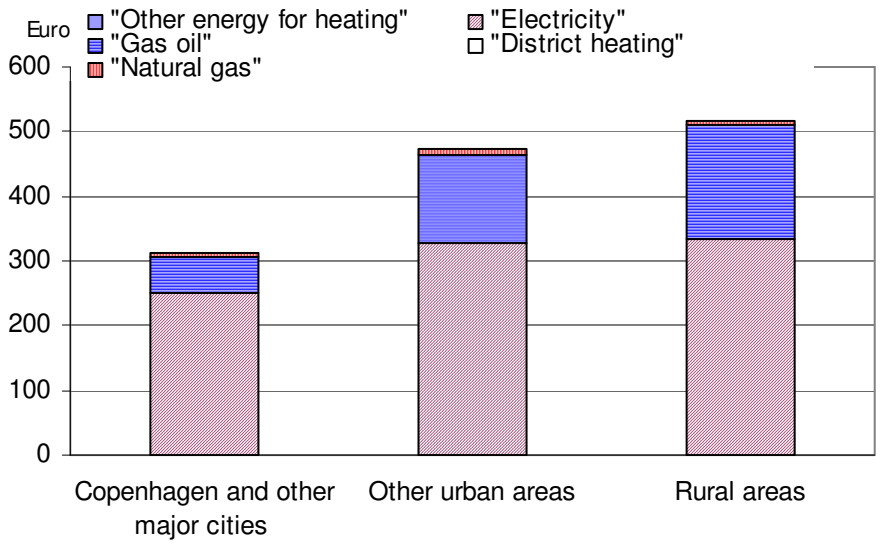

Figure 4 Energy taxation of households 1997

Energy taxation of households is calculated based on the actual reported energy consumption and tax rates for 1997 including CO_2 taxes[9]. The major part of taxation is electricity tax, which is paid by all households. Tax on gas oil is also important, even though only a minority pays it. Rural households tax payments are 66% higher than those of urban households, even though their energy consumption is only 26% higher. The large amount of gas oil heating for this group therefore seems quite unfavourable, as does their relatively high electricity consumption.

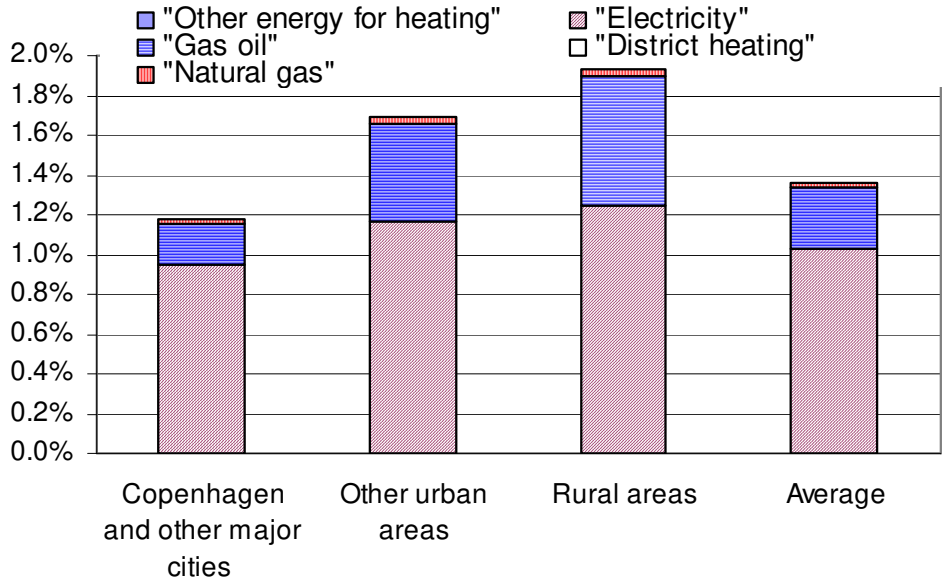

Figure 5 Energy taxes as a proportion of disposable income in households 1997

The tax payment is then compared to the disposable income of households to produce a measure of the burden of taxes for the different groups of households. The higher tax

[9] Transport energy (petrol etc.) is not included in these figures.

payment for rural households is reflected in the proportion of income used for taxes, as given in Figure 5.

Rural households use 67% more of their income on the taxes than do urban households. This is the same relative difference as for tax payments. The lower rural income observed in Figure 1 (7.5% lower than in Copenhagen) is per adult and with larger average household size in the countryside the **household** income is at the same level as in Copenhagen and large cities. For other urban areas the tax share of income reflects the higher household income. The tax share of income in Figure 5 thus even further stresses the unfavourable position of rural households relative to the tax payments that could be observed in Figure 4.

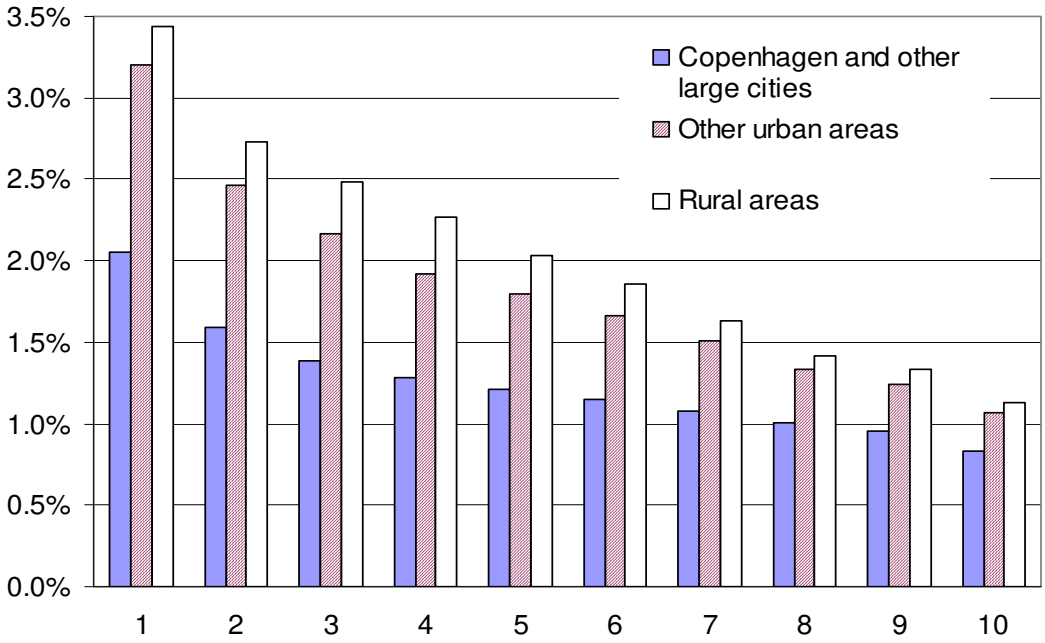

Figure 6 Energy taxes as proportion of disposable income for income deciles

Income variations for income deciles were shown in Figure 1, showing a lower variation in the rural households. The variation in energy tax share of income is given in Figure 6 for the three regional categories.

The higher taxes paid by the rural households are also reflected if examined for all the income deciles. The property of regressivity of energy taxes is more pronounced for the rural households. The households in the first decile use close to 3.5% of their income on energy taxes, whereas the same income group in urban areas use only 2% of their income on these taxes. Therefore low-income households in rural areas will be especially hurt by increased taxes. However, this group is less than 1% of the population. It might be possible that a correspondingly small group of low-income pensioners in urban areas will be similarly affected, but the average pensioner in urban areas or the lowest income decile will not be affected as much. The category of other urban areas also shows a tendency towards higher regressivity than Copenhagen.

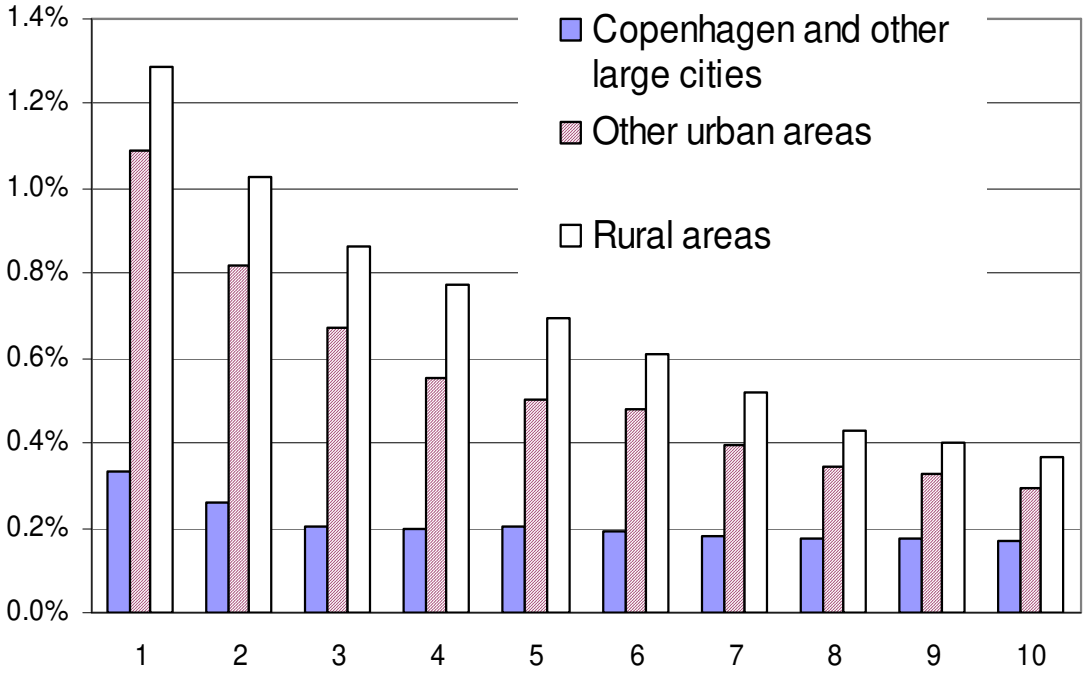

Figure 7 Gas oil tax as a proportion of disposable income 1997

Gas oil tax is one of the regressive taxes. This is especially evident for the population living in rural areas, as can be seen from the much higher proportion of income used for this tax in rural areas (lowest income decile 1.29% relative to highest income decile 0.37%). For all of the population gas oil is not more regressive than other energy taxes. The larger variation for the tax share of rural households' income is a result of less variation in the consumption of gas oil among the rural households. The lowest income decile in Copenhagen uses 28% less than the urban average, whereas the lowest income decile in rural areas uses only 5% less than the average. Thus the overall regressivity of the gas oil tax is moderated by the low coverage of gas oil heating among the urban low-income groups. Gas oil heating is used in 21% of the households on average, with very little variation between the income deciles.

It should also not be forgotten that the households with gas oil have a more flexible technology choice than households connected to the grid because they are able to change their fuel supply. Households using gas oil in rural areas are not restricted by legislation in their technology choice as are households connected to the grid.

To expand the analyses, other environmental taxes have been examined, apart from those included so far. Transport-related taxes are of a considerable size and two major transport taxes are included in Figure 8, namely registration duty and petrol tax. The figure compares the burden of taxes paid in five different regions of which the first three correspond to Copenhagen and other major city municipalities.

Taxes are examined relative to disposable income for six different environmental taxes. The taxes included in the discussion so far include electricity, CO_2, gas oil, and some other minor taxes on heating. However, these taxes only constitute around 25% of total environmental taxes in Denmark for the year 1997. The additional taxes included in Figure 8 further stress the regional difference with respect to the burden of environmental taxes.

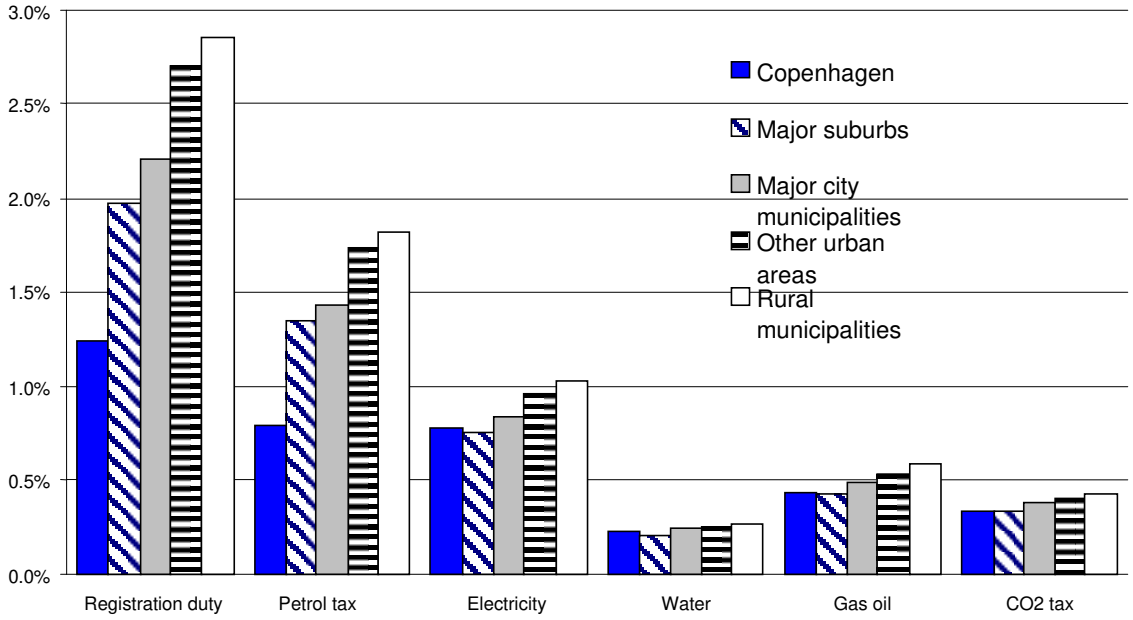

Figure 8 Residential location and selected environmental taxes

Rural households pay a higher proportion of their income on environmental taxes than households located in cities. This goes for all taxes included in Figure 8, and the relationship 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 even more pronounced for registration duties and petrol taxes than for energy 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. The general conclusion is that the impact on rural households from environmental taxes is higher than for other parts of the population.

If all the environmental taxes from Figure 8 are added together, on average rural households use 7.0% of their disposable income on these taxes and their urban counterparts (Copenhagen) use only 3.8%. The difference with regard to total energy bills is less, as the grid-connected heating technologies embody much higher capital cost as a countermeasure to their lower energy cost, and especially their low-taxed status.

For the lowest income decile in rural areas, this means that close to 15% of disposable income is spent on energy and environmental taxes.

5. Policy implications

The different tax burden for households living in different regions of the country is partly a result of the historical energy tax policy. The tax structure has successfully provided incentives for expanding the district-heating and natural gas grids by either directly or indirectly excluding these from energy taxes. The taxation of gas oil and especially electricity has been a major way of inducing the shift from individual-based heating (electricity, gas oil and kerosene) to grid-based heating.

Taxation of households is introduced to some extent on the basis of environmental concerns. The fact that households in rural areas pay higher environmental taxes is of course related to their energy consumption and indirectly to their contribution to environmental pressure and damage. These households should pay a tax that corresponds to the marginal

damage of their energy consumption. However, this assumes that households have the option of reducing their energy consumption, or changing technology. In rural areas there is no possibility of changing to district heating and only limited access to natural gas. The high energy taxes have certainly also contributed to the widespread use of straw and wood pellets etc. in rural areas. This is evident in Figure 2 that shows 5.9% of energy consumption is other energy in rural areas, where the corresponding figure in Copenhagen is just 2.4% of total energy consumption.

Furthermore, the transport needs in rural areas tend to make car use a primary necessity in contrast to cities. The basic question is therefore on the choice of where to live. Maybe the lower living costs (housing) offset the higher energy (tax) costs associated with living in rural areas.

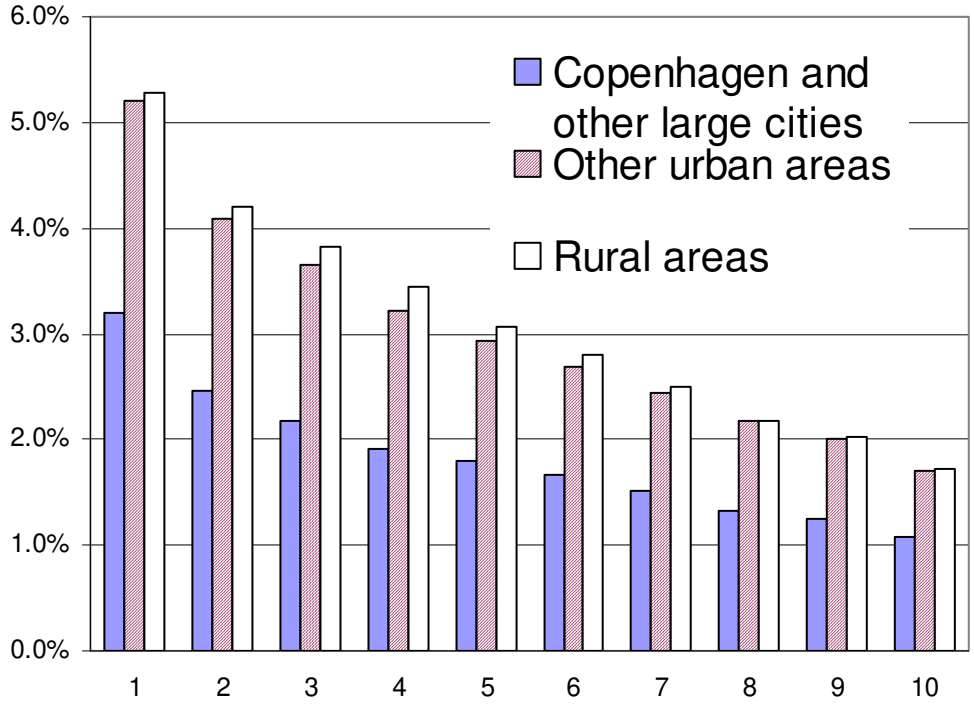

Figure 9 Tax impact with standardised taxes for 2000

To illustrate the effect of having more standardised tax rates reflecting the energy content, the implications for the different regional and income groups have been calculated. This implies using the actual tax rates on energy for 2000 and additionally including a tax for district heating and for other energy that is set equal to the tax rate per MJ for natural gas.

The overall proportion of taxes relative to income in Figure 9 is higher than in Figure 6 because actual tax rates have increased from 1997 to 2000, and the inclusion of hypothetical taxes for district heating[10] and other energy increase total energy taxes. An additional difference is that income figures have not been adjusted and thus are the actual 1997 income data.

The more standardised taxes result in a more equal tax burden for rural areas and other urban areas. These two categories mainly consist of households living in detached houses.

[10] There is actually an indirect energy tax on district heating because a coal tax for the large Combined Heat and Power (CHP) plants in Denmark has been implemented and in the last couple of years also more rigorously enforced.

Still the burden of taxes for Copenhagen households is smaller, but this is largely a result of a large proportion of households living in apartments. Therefore the average size in square meters, and also the energy loss during wintertime, is lower in urban areas, resulting in lower energy consumption and less tax payment.

The main conclusion of energy taxes being regressive both in urban as well as rural areas remains intact. However, the regressivity for urban households seems to increase with the taxes for 2000 including the tax for district heating. This is not the case for rural households, where the difference in tax payments from the 1st to 10th. deciles is about the same.

6. CONCLUDING REMARKS

Rural households in Denmark have only marginally lower income than urban households, contrary to what is often expected and what has historically been the dominant tendency.

Energy consumption on the other hand and the burden of energy taxes is not evenly distributed across regions and income groups. The results from this study show that households in rural areas use more energy than households in urban areas. One of the major explanations for this is that the major proportion of dwellings in rural areas consist of detached houses, compared to more equal numbers of detached houses and apartments in urban areas.

The marginally lower incomes in rural households result in an even higher proportion of income being spent on energy taxes for the rural households. Also the composition of energy consumption in rural households increases their relative tax payments. The much higher use of gas oil in rural households leads to energy taxes being around 1.9% of income in rural areas compared to only 1.2% in Copenhagen.

The energy taxes were also found to be regressive independent on the area of living. However, also in this case regressivity is more pronounced in rural areas were the least well off spend 3.4% of income on energy taxes with the same income group in Copenhagen spending only 2.1% of income on these taxes.

The main conclusion is that the tax burden for households living in rural areas is considerably higher than for households living in urban areas.

In addition to the different impacts of energy taxes, transport-related taxes (registration duty and petrol tax) are even more disproportionately distributed between rural and urban households. Rural households in the lowest income decile use almost 15% of disposable income on energy and environmental taxes in total where the corresponding figure for urban households is only around 6%.

This does not in general reflect that rural households pollute more than urban households. At least their energy consumption is in line with the energy consumption of people living in the same type of dwelling in the urban areas.

The solution is not to differentiate taxes across the country, but the difference between taxation of different fuels for heating is unfavourable to rural households and should be taken into account. Secondly, the importance of having alternative heating technologies available, and especially the importance of having transport alternatives for cars is vital if rural households are to be able to reduce the burden of these taxes.

Increases in tax on natural gas in 2000 reduce the difference, and the more rigorously enforced coal tax on district heating in recent years has contributed to reducing the excess tax burden on rural households.

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REFERENCES

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

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.

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.