Environmental tax reform in Europe: implications for income distribution

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Executive summary

Key messages

- Although ETRs tend to improve incomes across society, they can have mild regressive impacts in that richer households gain more than poorer ones.
- Care is needed to design ETRs in ways that ensure that certain groups are able to benefit equally.
- ETR's overall benefits for the economy, environment and society are potentially significant.
- ETR should therefore be regarded as a key element in the policymaking toolkit for shifting to a green economy.

In a series of reports on environmental tax reform (ETR), published in 2005, the EEA defined ETR as 'reform of the national tax system where there is a shift of the burden of taxes, for example on labour, to environmentally damaging activities, such as resource use or pollution'.

At the most basic level, therefore, ETR comprises two elements. First, it deters environmentally damaging activities by making them more costly. This can obviously be desirable for numerous reasons, including reducing harm to environments that we value for recreation or their cultural importance; alleviating the pollution that can impact human health and standards of living; and preserving the natural resources and systems that sustain our societies and economies — both today and for future generations.

But the second aspect of ETR is no less important. It involves recycling the revenues gained from increased environmental taxes and using them to create positive economic and social outcomes, such as increasing employment and boosting incentives to work. The recycling of revenues is especially important for the acceptability and equity of the tax reforms. This is because shifting the burden of tax increases some costs and reduces others, and since no two individuals in society will have exactly the same earning and spending patterns, the impacts will vary.

For example, essentials such as energy and food may account for a larger proportion of the consumption spending of poorer households, so measures that increase energy and food prices could well affect those households disproportionately. Contrastingly, reducing taxes on income will benefit those with jobs more than unemployed or retired people.

In fact, ETR can produce (at least) four different types of impacts, each of which may be distributed unequally across society. These comprise the direct consequences of increasing taxes (e.g. higher prices for certain goods); the consequences of recycling (e.g. direct transfers or alleviation of taxes); the broader economic impacts of ETR (e.g. job creation or inflation); and the environmental effects of ETR (e.g. a cleaner environment).

Policymakers need to understand these impacts and their interplay if they are to maximise the aggregate gains from environmental tax reforms, while respecting individual rights to an equitable sharing of costs and benefits. The present study aims to enhance understanding of these effects, analysing them using two approaches. Chapter 2 comprises a review of relevant literature on ETR's theoretical and empirical distribution impacts in Europe. Chapter 3 contains a model-based analysis of ETR at the EU-27 level. Chapter 4 combines these two approaches — literature review and modelling — to provide a more detailed analysis of the distribution of an ETR's impacts in Germany.

Literature review of ETR impacts in Europe

The review of literature on ETR's distributional impacts in Europe revealed some clear trends. First, the distributional effects of environment-related taxes vary across Europe. Energy and carbon taxes tend to be weakly regressive in some countries and more strongly regressive in others, notably the United Kingdom. Whereas those taxes tend to put the highest relative burden on the lowest-income households, motor fuel taxes normally impose the greatest onus on middle-income groups (because poorer households are less likely to own cars). In rural areas, however, car ownership is often less optional, meaning that low-income rural households tend to bear a heavy burden from environment-related taxes, especially motor fuel taxes.

Analysis of specific ETR packages in Sweden and Germany tends to confirm these broad findings. In Sweden, the ETR increased disposable incomes for most groups, although the highest- and lowest-income groups experienced declines. Rural households also fared less well than urban ones.

The wider economic and social implications of ETRs are arguably more striking. In Germany, recycling of ETR revenues has stabilised and even cut pension contributions, which were previously climbing steadily. It also created a significant number of new jobs, estimated at 250 000 in 2003, which corresponds to employment levels 0.75 % above the reference scenario. The job creation is thought to have partially offset some of the negative distributional effect.

In terms of the distribution of environmental benefits resulting from the ETRs, the findings are less clear. Since the lower-income groups tend to endure worse environmental conditions, environmental improvements are likely to have progressive impacts. Unfortunately, analysing these impacts and their distribution is very difficult because of the cost and complexity of quantifying and valuing impacts, and demonstrating cause and effect relationships. (Indeed, these same characteristics partly explain why these impacts are externalised from market prices to begin with.) The limited evidence available does suggest, however, that poorer households benefit disproportionately from reduced pollution.

The literature review also revealed a variety of national measures used to address distributional impacts. These included efforts to design and target the taxes so that they are not regressive, and organising a system for redistributing revenues so that it offsets regressive fiscal outcomes.

Focusing on the tax base, it appears that in many countries there is limited political scope to increase energy taxes, which have been by far the most commonly applied taxes in ETR. Fuel tax increases coinciding with high oil prices have led to massive protests and policy changes. The hardships imposed on poor households by high energy costs have also become a subject of intensive debate.

At the same time, energy taxes tend to have a price-stabilising effect as their amount is not affected by the price volatility of energy and carbon markets. They therefore help provide a long-term price signal to induce behavioural change and investments. Perhaps most fundamentally, it is clear that keeping the prices for energy and other environmental resources low cannot be considered an appropriate way of achieving social policy objectives. Instead, measures should be designed to improve the situation of poor households while keeping the incentive to save energy and other resources.

Shifting the focus, therefore, to mechanisms for redistributing revenues, countries have used a variety of approaches. This diversity appears to reflect the fact that designing a system that corrects distributional problems while maintaining the right environmental and economic incentives, and ensuring the ETR's political acceptability, is no easy task.

One option is transfer payments specifically designed to cover energy. However, these are arguably problematic from both the environmental and fiscal points of view: they remove the incentive for the recipient to save energy and, by encouraging excess consumption, strain public budgets to an unnecessary extent.

As an alternative, the 'eco-bonus' concept (whereby per-capita refunds are distributed across the population) has been found to neutralise regressive impacts effectively. However, automatic redistribution reduces the function of ecotaxes to steering environmental incentives, while completely forsaking their revenue-raising function. It would also mean giving up the 'double dividend' of also generating employment by lowering labour costs.

Several writers advocate treating ETR as part of a comprehensive reform package. Fiscal and social policies (such as adjusting income tax and child allowance) can largely offset distributional problems and deliver economic benefits too, potentially making this a better solution than building all correction factors into the environmental policy package itself. However, where there is only a weak link between environmental taxation and compensation measures applied in other areas, the compensation measures may not counteract the general perception that environmental taxes are socially unfair.

Modelling ETR in the EU-27

At the European level, an assessment of the distributional impacts of ETR was carried out using the E3ME model, which includes 13 different socio-economic groups, including five income quintiles, six groups defined by employment status (including retired) and urban and rural splits. The ETR modelled in the exercise comprised imposing a tax on energy and material inputs, and delivering a corresponding reduction in employers' social security contributions and income taxes.

The modelling results showed that, at the aggregated EU level, the ETR would generally create a positive change in real incomes for all socio-economic groups. However, different socio-economic groups may gain by different amounts according to their income status, their employment status or whether they live in an urban or rural area.

Groups that do not pay income taxes generally see a smaller increase in their real incomes than employed households because they do not benefit from reduced income taxes. A similar divide can be seen between the urban and rural groups. For both groups there is a positive change in real incomes but in all scenarios the urban population experiences greater increases than the rural group due to the smaller amount they spend on both transport and heating fuels.

Switching the focus from socio-economic groups to income classes, the lowest-income group might have been expected to gain least. In fact, the results in fact show that middle-income groups, particularly the third quintile, see the smallest increase in their real incomes. This results from the larger share of their income spent on both transport fuels and heating costs. The highest income group does not devote as large a proportion of its income to these expenditures whilst individuals within the lowest income group often do not own cars so do not encounter the associated increase in fuel costs.

These results are broadly consistent with those discussed in the literature review in this report. Then again, there are several countries in which the lowest income quintile actually experiences no real income growth or even a slight fall, suggesting that the trade-off between decreased income taxes and increased fuel costs is negative. Furthermore, it can be seen that in these particular countries there is a big difference between the gains experienced by the richest and the poorest quintiles, suggesting that ETR could in fact create a less equal distribution of income. This is highly undesirable for policymakers as the vulnerable groups of the population such as the poor or unemployed are most likely to require social protection and should not automatically be disadvantaged by a change in policy.

In sum, the results show that ETR can increase real incomes for all groups and hence encourage employment, supporting the case for future ETR in the EU. In most countries, and at the aggregate EU level, the impacts were not found to be regressive across income groups. However, the gains in income for different socio-economic groups are not necessarily equal, creating an unfavourable distribution of income, which could be made worse if more ambitious targets for reductions in emissions and material consumption were set. ETR could therefore be challenged by interest groups or individuals with income groups that lose out from the reforms. Alternative arrangements for support may therefore be required to make ETR politically feasible.

Literature and modelling analysis of ETR in Germany

Chapter 4 presents an analysis of the quantitative repercussions of an ETR in German economy using the PANTA RHEI and DEMOS models. It focuses on the consumption patterns of 25 types of households, assessing the impacts of an increase in the carbon price to EUR 68/t CO_2 in 2020 compared to a baseline scenario. Such an increase is projected to boost the price for 'electricity, gas and other fuels' by 21 % and the price for 'operation of personal transport equipment' by 15 %.

The results indicate that the proposed ETR would put a disproportionately high burden on lower-income households, which do not benefit from reduced social security contributions, including the unemployed and the retirees. Such groups bear the highest burdens in terms of additional expenditure for environment-related goods and services whose prices change due to the ETR. This is especially true of energy expenditure.

The increases in consumption expenditure as a proportion of disposable income for employee households (which make up the middle class) are close to the average for all household, even though their nominal expenditure on motor fuels rises disproportionately. The reform puts the lowest relative burden on the self-employed, which comprise the highest-income group under consideration.

In sum, the projected outcome is regressive. Although the ETR increases consumption spending as a proportion of disposable income for all groups, it puts the heaviest burden on the lowest earners. And because these groups are indebted, the average effect (other things being equal) is to increase their indebtedness.

Perhaps the most striking finding, however, is that the impacts are very minimal. The maximum additional spending on energy as a proportion of disposable income is just 1 % — indicating that it would be relatively simple and affordable to compensate for the uneven distribution. In this context the macroeconomic effects of the reform are particularly relevant. The study shows that as ETR revenues are recycled via reductions in social security contributions, labour costs decrease, which is the main driver for additional employment of 152 000 in 2020 against the baseline. This could potentially correct some of the negative impacts on unemployed or inactive households. In addition, disposable incomes increase slightly at the national level. Part of this additional income could be redistributed in order to correct the ETR's regressive effects.

In conclusion, the modelled ETR can potentially deliver a double dividend, increasing employment and improving the environment. However, the policy would need to be formulated carefully and in detail in order to minimise negative impacts on particular socio-economic groups and ensure an equitable outcome for the poorest households.

1 Introduction

1.1 Background

In 2005, the European Environment Agency (EEA) prepared a series of reports on the use of market-based instruments to achieve environmental goals. Environmental tax reform — defined as 'reform of the national tax system where there is a shift of the burden of taxes, for example on labour, to environmentally damaging activities, such as resource use or pollution' — was identified as a key tool in this context (EEA, 2005).

A central attraction of ETR is its capacity to steer incentives so that human endeavour and ingenuity can deliver maximum economic gains, while preserving the environment and social equity. To analyse this function further, the Anglo-German Foundation (AGF) commissioned a major body of research commissioned in 2007, 'Creating sustainable growth in Europe'. One project in this context, entitled 'Resource productivity, environmental tax reform and sustainable growth in Europe' (petre), started from the hypothesis that ETR could increase human well-being via two routes: improving the environment and generating economic activity and employment. The results of petre were presented in a final report (Ekins, 2009) and in a book (Ekins and Speck, 2011).

Petre used econometric and resource flow modelling techniques, surveys, and interviews to explore the implications — for Europe and the rest of the world — of a large-scale ETR in Europe designed to achieve the EU's 2020 greenhouse gas reduction targets, i.e. cutting GHG emissions by 20 % in the period 1990–2020 (or 30 % in a context of global cooperation). In order to investigate whether ETR could deliver these targets, six 'scenarios' were developed and modelled, using two well-known macro-econometric models: E3ME and GINFORS ([1]).

The results suggested that ETR is an effective environmental instrument that can enable the EU to meet its CO_2 targets. The models produce nearly identical results concerning labour and resource productivity, signalling that an ETR that meets the emissions target would raise employment, lower resource consumption and have negligible effects on GDP.

The petre project provided a compelling case for using ETR more widely but the findings also indicated scope to extend the analysis. For example, the results of one of the scenarios indicated that investment in green technologies in the EU could significantly reduce both the carbon price and GDP loss in reaching the 20 % target. Measures that could augment the net benefit of ETR are clearly worth exploring in more detail. Similarly, the petre project results also suggested that the varying national political, economic, institutional and cultural contexts across the EU-27 make introducing an ETR politically complex. Again, this suggested the need for additional analysis of ETR's social impacts to ensure that promising ideas can be translated into working policies.

In view of these findings, the EEA decided to commission a two-part study to analyse the issues in more detail. The first part focuses on links between ETR and eco-innovation and green technologies. The second addresses ETR's implications for the distribution of incomes across society.

Both of these issues are, of course, essential determinants of an ETR's potential contribution to sustainable growth and the shift to a green economy. Eco-innovation is an indispensible element in enhancing resource efficiency, i.e. delivering greater economic outputs and wellbeing at lower environmental impacts. Meanwhile distributional

([1]) See for more information with regard to the modelling framework the papers presented and to be downloaded at the website of the project (www.petre.org.uk) or Ekins and Speck (2011) and in particular Chapter 8 thereof.

impacts are central to an ETR's political acceptability and social equity — another essential aspect of sustainability. Any serious attempts to design ETRs must therefore include a focus on eco-innovation and distributional impacts. The present two-part study aims to contribute to the knowledge base for that analysis.

1.2 Distributional impacts of ETR

Environmental tax reform (ETR) is a potentially important tool to address environmental challenges both today in the decades ahead. Wider implementation of ETR has been hindered, however, by equity concerns — specifically the belief that a disproportionate burden may fall on low-income and rural households.

These concerns are a priority in the EU. The European Commission's Impact Assessment Guidelines (EC, 2009) underline that social inclusion and the protection of particular groups must be considered ahead of any proposed changes in policy or regulation. Specifically, they call on decision-makers to consider whether 'the option affects specific groups of individuals (for example the most vulnerable, or the most at risk of poverty, children, women, elderly, the disabled, unemployed or ethnic, linguistic and religious minorities, asylum seekers), firms or other organisations or localities more than others?'

For policymakers, this raises more important questions. To what extent has ETR had this effect in the past? And are inequitable outcomes a characteristic of all ETR or just badly designed reforms? The present report aims to provide some answers to those questions, augmenting the knowledge base on social consequences of ETR, which is currently rather limited. It consists of three separate analyses, addressing the distributional implications both qualitatively and quantitatively.

The qualitative analysis in Chapter 2 is based on a literature review. It reviews theoretical and empirical findings on the distributional effects of environmental taxes and tax reforms, and policy options to mitigate or reverse undesired distributional effects.

Chapters 3 and 4 present modelling studies of the impacts of an ETR on the distribution of income across individuals and households. Chapter 3 analyses the implications for households (split according to income, employment status and location) of a broad-based ETR, as this issue is clearly one of the main challenges to ETR's political acceptability. The focus is on implications at the European level, i.e. covering all 27 EU Member States.

Chapter 4 analyses in more detail the implications of ETR on households in a single country: Germany. Using the PANTA RHEI and DEMOS models, it shows the quantitative repercussions of an ETR for the German economy concentrating on consumption patterns of 25 types of households in the year 2020.

2 Distributional impacts of environment-related taxes and ETR: a literature review

This chapter provides a literature review of the distributional impacts of environment-related taxes and environmental tax reform (ETR) on private households. ETR's distributional effects can be grouped into four clusters:

- **Direct consequences of the increased environmental taxes** for each socio-economic group. These consequences are related to the expenditures by the different groups on the goods and services that are taxed. The central problem is that excise taxes have often been found to have a regressive effect, i.e. poorer population groups pay a larger proportion of their income than richer population groups.
- **Direct consequences for these socio-economic groups from recycling environmental tax revenues** by reducing taxation of labour (both employer contributions and income tax). The concept of ETR includes both imposing taxes on environmentally harmful activities and redistributing the revenues levied.
- Other effects are not of a directly financial nature but arise from the **broader economic impacts of ETR.** These include macroeconomic effects such as impacts on employment. ETR will change relative prices throughout the economy and these will have varying effects on different groups. E3ME models these changes through input-output relationships and sectoral rates of cost transferral.
- **Environmental effects of the ETR** on different socio-economic groups. There is now substantial evidence that, as might be expected, lower income groups generally experience lower environmental quality than higher income groups. To the extent that ETR improves environmental quality (which of course is one of its principal objectives), it is likely that these environmental benefits will be differentially distributed among households.

Finally, ETR design may include **exemptions and other provisions to help achieve economic, social or environmental goals**. These can be seen as part of the first two sets of effects listed above but should be addressed separately because they constitute deviations from the basic ETR design.

Section 2.1 will look at theoretical and empirical findings on the distributional effects of environmental tax reforms along the lines described above, addressing the distributional effects of the taxes themselves; net effects when including revenue redistribution; and wider economic and social implications.

Section 2.2 presents the literature on policy options to mitigate or reverse negative distributional effects. Section 2.3 presents conclusions to inform further discussion and analysis.

2.1 Distributional effects of environment-related taxes and ETR

2.1.1 Distributional effects of environment-related taxes

A considerable amount of literature has analysed the distributional effects of environmental taxes on households. Meta-analyses include those by OECD (1995), Speck (1999), Speck et al. (2006), Leipprand et al. (2007) and Peter et al. (2007).

Motor fuel taxes tend to put the highest relative burden on middle-income groups

In contrast to taxes on labour, energy taxes have generally been found to have regressive implications. However, this general finding may not reflect reality in all circumstances. Certainly, various studies demonstrate that ETR focusing on household energy use has significant regressive effects, with the lowest income groups bearing the largest tax burden relative to their income. In contrast, however, motor fuel taxes tend to put the highest relative burden on middle-income groups. This is because car ownership is lower in low-income households, and households without cars are not directly affected by motor fuel taxes. In addition, the effects of motor fuel taxes are also influenced by country- and region-specific factors, such as the overall distribution of income, the energy supply structure, energy-efficiency characteristics of domestic fuel use and reliance on car transport.

The distributional effects of transport-related taxes are examined in detail in a Norwegian study (Aasness and Larson, 2002). The authors do not analyse any specific taxes, or taxation schemes, but examine elasticities of household expenditure on various transport-related items and relate this to the environmental effects of different modes of transport. They distinguish between 'high-pollution luxury modes' of transport such as flight and taxi, and 'low-pollution necessary modes' of transport such as buses, bicycles and mopeds. They conclude that imposing higher taxes on the former and lower taxes on the latter would serve both environmental and equity objectives.

With regard to private car transport, they observe that high taxation of petrol is desirable from an environmental point of view but it also increases inequality. They argue that higher vehicle taxes may serve equity purposes better. Whereas petrol varies little in quality, the quality of automobiles can differ significantly between basic and luxury versions, leading to much higher elasticity of expenditure. Meanwhile, taxing railway passenger transport was found to be distributionally neutral.

Distributional effects of environment-related taxes vary across Europe

Leipprand et al. (2007) examined the distributional effects of environment-related taxes and charges in five European countries: the Czech Republic, Germany, Spain, Sweden and the United Kingdom. The analysis included energy taxes as well as charges on water services and waste collection. The amount spent on these taxes and charges was related to average disposable household income of different income classes (deciles of the total income distribution for most countries) and other categorisations of household groups (activity and employment status, household size and structure, age, number of active persons, and degree of urbanisation).

In the case of energy taxes, the tax burden was calculated by converting expenditure statistics into physical consumption estimates and relating the amounts of physical consumption to the tax rate applied in each country. For water services and refuse collection, expenditure data were used as a proxy for charge levels, since in these areas charges are difficult to separate from prices, and charging systems vary regionally and even locally.

An admitted shortcoming of the methodology was the static analysis. It was only based on current expenditure and did not take into account dynamic effects, i.e. the fiscal incentives to change consumption patterns, which may in turn reduce the tax or charge burdens on individual households in absolute terms.

As Figure 2.1 illustrates, the study found evidence of regressive impacts in the Czech Republic. Although differences between income groups are not substantial, the largest difference is between the lowest income group and the second lowest.

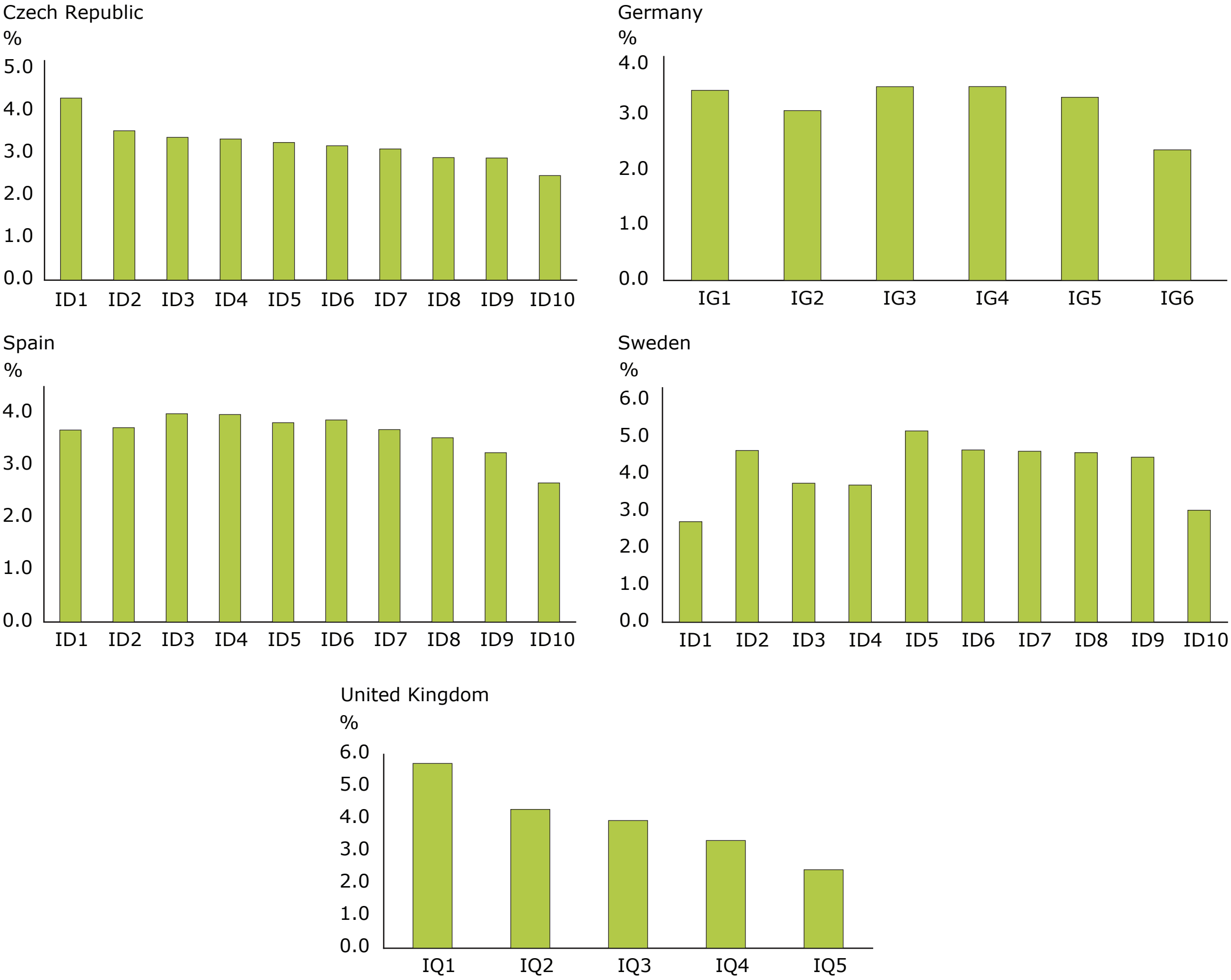
In Germany there was evidence of regressive impacts but mostly for tax instruments constituting a relatively small share of the total environment-related tax and charge burden. When total sums are considered, these regressive elements are masked by the dominant role of motor fuel taxes. Most of the environment-related tax revenue in Germany derives from the transport sector (fuel taxes on petrol and diesel), while regressive effects are largest in the area of household energy (i.e. relating to electricity tax and petroleum tax on heating fuel).

In Spain, water charges produce significant regressive impacts. In the aggregate figures for environment-related taxes and charges, however, these impacts are masked by the more progressive distribution of motor fuel taxes.

There is almost no evidence of environmental taxes having regressive impacts in Sweden. The self-employed seem to be the most disproportionately burdened group but there seems to be no cause for concern regarding other vulnerable groups, such as the unemployed or single parent families.

In the United Kingdom, the sum of environmental taxes and charges clearly has a regressive impact on households, with the proportion of income paid decreasing consistently as income levels rise. The strong regressive impact of water charges determines the overall trend of the total, while motor fuel taxes follow the usual pattern, with middle-income groups paying most as a proportion of their income. The regressive effect of water charges is essentially the result of pricing that is usually unrelated to the actual quantity of water consumed.

Figure 2.1 Selected environment-related taxes and charges as a percentage of average disposable household income, by income groups



Note: Income distribution is clustered into deciles for the Czech Republic, Spain and Sweden, sextiles for Germany and quintiles for the United Kingdom.

Source: Leipprand et al., 2007.

Energy and carbon taxes tend to be weakly regressive in some countries and more strongly regressive in others, notably the United Kingdom

In the 1990s, several studies examined the distributional effects of introducing energy or carbon taxes. Smith (1992) undertook an early comprehensive study, relying primarily on EU household expenditure surveys for six countries. The analysis was mainly static, assuming no indirect effects, no induced changes in demand patterns and full passing on of taxes to prices. Under these assumptions, the ratio of regressivity was calculated for 11 countries. The study concluded that carbon and energy taxes were weakly regressive for most countries but more strongly regressive for the United Kingdom and Ireland.

Barker and Köhler (1998) confirmed the regressive effect of energy and carbon taxes in the United Kingdom and Ireland, as well as in Germany, using a dynamic model of the effects of minimum EU excise taxes, as proposed by 11 EU Member States.

Symons et al. (1997) reached similar results in their analysis of income distribution impacts in Germany, Italy, Spain and the United Kingdom, based on a static modelling approach. The study found that a CO_2 tax and an energy tax would be regressive for Germany and the United Kingdom, with energy taxes slightly less regressive than CO_2 taxes. The impact of the taxes was found to be less regressive in Italy, and even slightly progressive in Spain. The Spanish outcome was attributed to the increasing proportion spent on petrol throughout the income distribution.

A later article by the same authors (Symons et al., 2002) found regressive effects for Germany, France and, to a lesser extent, for Spain, a nearly neutral effect for Italy but a progressive effect for the United Kingdom. They explain this unusual finding by the specific expenditure category weights applied in the statistical expenditure data on which the analysis was based — an example of how subtle changes in assumptions and underlying data can influence results to a considerable extent.

Interestingly, in examining the effects of removing subsidies for energy products in Poland, Freund and Wallich (1997) showed that middle- and high-income households spent, in relative terms, a larger share of their budget on energy products than low-income households. The findings are not transferable to other Member States due to historic (post-socialist) and country-specific conditions but they show that the negative correlation between household earnings and the income proportion spent on energy is not always valid.

The distributional impacts of energy taxation have been analysed in particular depth for the United Kingdom, which has also been found to be one of the countries where such problems are greatest. Regarding household energy, Ekins and Dresner (2004) concluded that a flat carbon tax on the entire population (both rich and poor) providing no compensation for low-income groups would be very regressive and increase the existing price burden on those groups. In addition to spending a larger percentage of their income on electricity, poorer households are less able and willing to switch to energy-efficient appliances due to financial restraints and the fact that many live in rented accommodation. Another problem is that variation in the distributional impact within income groups makes it hard to compensate certain segments of the population.

Similarly, a study by McNally and Mabey (1999) demonstrated that a tax on domestic energy consumption would be financially regressive for lower income households, as domestic energy is a necessity good. Focusing on the effects on energy consumption of applying value added tax to domestic energy, Crawford et al. (1993) estimated that while the average consumption of UK households would fall by nearly 6 %, average energy consumption in the bottom income quintile would fall by 9 %, while average consumption of the richest quintile will be reduced by only 1 %. This implies that, in addition to bearing the greatest financial impact (as a proportion of incomes), low-income households also account for the largest proportional reduction in energy consumption.

Rural households tend to be disproportionately burdened by environment-related taxes, especially motor fuel taxes

According Ekins and Dresner (2004) and McNally and Mabey (1999), motor fuel taxes are generally considered progressive because they affect the portion of the population who possess cars and not the poorest households, who generally do not. However, this is untrue for many poorer households in rural areas who travel further, use more fuel and have less access to public transportation. McNally and Mabey (1999) have concluded that poor rural households suffer the most from motor fuel taxes. In addition, urban low-income households owning a car will be less able or willing to switch to a more fuel-efficient car. Therefore, although fuel taxes are mainly progressive, a minority of low-income motorists would be disadvantaged.

Several studies have found that environmental taxes in Sweden clearly disadvantaged rural inhabitants (Speck et al., 2006; Leipprand, 2007; Peter et al., 2007). This conclusion is also reached in an academic study simulating the effects of doubling the CO_2 tax (Brännlund and Nordström, 2004) and an ex-post assessment carried out by the Swedish government (Government of Sweden, 2004).

Peter et al. (2007) compare the situations in Sweden and Switzerland and note that Switzerland has a relatively better developed public transport system. As a result, the distributional effects of energy or CO_2 taxation between Swiss urban and rural regions would be less pronounced. This highlights the importance of behavioural alternatives to avoid burdening certain population groups excessively. Peter et al. (2007) nevertheless emphasise that adverse distributional effects of energy taxes on rural regions remain an important issue, which has also been examined in more depth in earlier studies for Switzerland (e.g. INFRAS/ECOPLAN, 1998).

Rural households tend not only to have higher demand for motorised transport but also consume more household energy (Wier et al., 2005; Speck et al., 2006). A Danish study (Wier et al., 2005) distinguishes between direct and indirect CO_2 tax payments (the latter resulting from price effects in the purchase of energy-intensive goods and services when CO_2 taxes are imposed on industry). It concludes that in Denmark, the higher direct tax burden on rural households is partly offset by their lower indirect tax payments. A net disadvantage for rural households remains but is fairly small (adding an additional 0.04 percentage points to the CO_2 tax's share in disposable income).

The distinction made by Wier et al. (2005) between direct and indirect CO_2 taxation of households is also interesting in a broader sense. They conclude that the regressive effect of indirect CO_2 taxation is generally less pronounced than the effect of direct CO_2 taxation.

2.1.2 *Net distributional effects of environmental tax reforms*

Peter et al. (2007) compare the effects of energy taxes in various European countries (Denmark, Finland, Germany, the Netherlands, Norway, Sweden and the United Kingdom), based on a review of country-specific evaluations. In addition to assessing environmental and economic effects, the analysis addresses distributional effects, including revenue redistribution resulting from environmental tax reforms.

The study confirmed the generally regressive effect of energy and CO_2 taxes on households. It also found that in most of the countries analysed the energy tax burden on households was greater than the burden on industry. This is due to tax exemptions granted to energy-intensive industries for competitiveness purposes and due to the lower demand elasticity in the household sector. The authors also point out that price increases resulting from higher energy prices tend to be passed on from industry to households.

When redistribution and tax design are included in the analysis, Peter et al. (2007) found that the regressive effect of an ETR was nearly neutralised in the Netherlands and Sweden, albeit in very different ways in each country. In the Netherlands, every household is allowed a basic amount of electricity consumption free of taxation each year (see Section 2.2.1). Contrastingly, in Sweden most of the revenue was recycled via income tax reductions and a small part was used to reduce employers' labour tax contributions.

Sweden's 'green tax shift'

In Sweden, distributive impacts were a major concern from the outset of the 'green tax shift'. Accordingly, the government committed to consider income distribution effects, regional effects and impacts on industrial competitiveness. Generally, the tax shift has led to a change in the distribution of the tax burden and tax relief between households and firms, with households experiencing a net tax reduction and service firms experiencing a net increase in taxation (Leipprand et al., 2007).

In 2004, the Swedish government itself evaluated the effects of the green tax shift on households in the period 2001–2003 (Government of Sweden, 2004). Importantly, almost all social groups benefited from the green tax shift, although the net effect was relatively small at less than 1 % of disposable income in all groups. The study found that:

- all income deciles acquired a net increase in annual disposable income (ranging from SEK 130 to 300), except for the lowest (SEK 190 decrease) and highest deciles (SEK 60 decrease);
- households with multiple incomes and no children acquired the largest net increase in their annual incomes;
- the net tax burden decreased in all regions both relatively and absolutely, with households in Gothenburg and Stockholm gaining the most and rural areas gaining less;
- the biggest differences in distributive effects are seen with respect to different types of housing.

Germany's ETR in 1999

Most studies evaluating the distributional effects of the German ETR concluded that the households sector was a net loser from the reform, whereas energy-intensive industries benefited (Hillebrand, 2000; Bach et al., 2001; GBG, 2004; Bach, 2005). The reason is that certain industries were granted extensive tax exemptions but profited fully from the revenue distribution element of the reform in terms of reduced pension payments.

More recent research reached a different conclusion, however, finding that the ETR was almost neutral for the households sector as a whole (Bach, 2009). The main reason for this revised assessment was that the new analysis, which focused on the distribution impacts in 2003, took into account not only the relief from lower social security contributions but also the effect of pension adjustments introduced by the ETR. Due to the particular rules governing the adjustment of pensions, the reduction in contributions led to increased pension payments to pensioners. This again confirms the observation that subtle changes in the design of an analysis may influence conclusions on distributional effects significantly.

Although the new study showed the net financial effect of the ETR on households to be nearly neutral, it still showed a slight regressive effect. At first glance, the impact appears to be of little significance in absolute terms, with the lowest income decile experiencing the highest net financial burden in relation to income (0.13 % of discretionary income compared to 0.02 % for the average household).

Table 2.1 Net income effects for private households' due to the German ETR in 2003 (percentage of disposable income)

Deciles net equivalent household income	One-adult house-holds without children	One-adult households with children		Couples				Other house-holds	Total house-holds	Ecotax alone (±)
		with 1 child	with 2 and more children	without child	with 1 child	with 2 children	with 3 and more children			
1st decile	+ 0.02	– 0.20	– 0.35	– 0.16	– 0.27	– 0.28	– 0.48	– 0.38	– 0.13	– 1.05
2nd decile	+ 0.16	– 0.21	– 0.28	– 0.13	– 0.25	– 0.31	– 0.50	– 0.15	– 0.10	– 0.98
3rd decile	+ 0.22	– 0.10	– 0.25	– 0.01	– 0.25	– 0.27	– 0.39	– 0.00	– 0.05	– 0.94
4th decile	+ 0.17	– 0.11	– 0.48	+ 0.04	– 0.15	– 0.23	– 0.32	+ 0.04	– 0.05	– 0.94
5th decile	+ 0.27	– 0.04	– 0.31	+ 0.08	– 0.15	– 0.17	– 0.25	+ 0.02	+ 0.01	– 0.86
6th decile	+ 0.22	– 0.00	– 0.21	+ 0.04	– 0.10	– 0.18	– 0.23	– 0.04	– 0.02	– 0.85
7th decile	+ 0.15	– 0.16	– 0.29	+ 0.06	– 0.05	– 0.12	– 0.18	+ 0.05	– 0.00	– 0.80
8th decile	+ 0.11	– 0.14	– 0.35	+ 0.03	– 0.03	– 0.10	– 0.16	– 0.02	– 0.01	– 0.73
9th decile	+ 0.05	– 0.10	– 0.22	+ 0.03	– 0.03	– 0.05	– 0.14	– 0.03	– 0.00	– 0.66
10th decile	– 0.02	– 0.15	– 0.17	+ 0.03	– 0.03	– 0.03	– 0.13	– 0.01	– 0.00	– 0.47
Total	+ 0.11	– 0.13	– 0.29	+ 0.03	– 0.08	– 0.13	– 0.24	– 0.03	– 0.02	– 0.75

Note: (±) Income effects as a result of energy taxes without the redistribution that was included in the ETR package, presented here for comparison purposes.

Source: Adapted from Bach, 2009.

However, further differentiation of households reveals that negative distributional effects are more pronounced for certain groups. Families with children are affected the most by the ETR. Single parents and parents with more than two children lose up to 0.5 % of their discretionary income. Contrastingly, single people and married couples without children experience positive effects (Table 2.1).

In general, households of jobholders experience positive or small negative cumulative effects from the ETR, while households of unemployed persons and pensioners experience no change in their cumulative tax burden. Households of self-employed profit only to a small extent from reduced pension contributions. Civil servants and non-working persons hardly benefit from reduced pensions contributions or adjusted social transfers (Bach et al., 2001; Bach, 2009).

2.1.3 *Wider economic and social implications of environmental tax reform*

On a positive note, the German ETR has helped stabilise and even lower the pension contributions paid by employers and employees. From yearly ecotax revenues of approximately EUR 18 billion, around 90 % are used to finance pensions. Although pension contributions rose again after 2002, they were still lower in 2009 (19.9 % of gross salary) than before the ETR's introduction in 1999 (20.3 %). Moreover, without ETR their level would be 1.7 percentage points higher at 21.6 %.

Both proponents and opponents of ETR argue that the pension contribution-stabilising function of the German ETR has been its main guarantee for survival in a changing political environment. It convinced politicians responsible for setting taxes that they needed to keep this instrument, regardless of their ideological preferences

Job creation

Job creation has been an official goal of many environmental tax reforms. In the German case, modelling by Kohlhaas (2005) indicates that the biggest employment effect was reached in 2003, with 250 000 additional jobs, equal to 0.75 % above the reference scenario without ETR. By 2010, the job effect was predicted to decrease to 0.5 % additional employment.

According to Kohlhaas' analysis, the ETR contributed to job creation primarily as a result of reduced non-wage labour costs. Energy-saving investments induced by the rise in energy taxes also contributed more short-term employment effects. The positive effect on job creation is expected to partially offset potential negative distributional effects of ETR on the unemployed, who may eventually benefit from the job-creating impact of the reform. However, no data is available on which social groups have actually benefited or will benefit from the increase in jobs (Leipprand et al., 2007).

Environmental improvements

The net distributional effect of environmental taxes can be defined to include the distribution of beneficial effects on the state of the environment.

There are some indications that the positive environmental effects of ETR are progressive, since lower income households tend to suffer more from environmental pollution (Pye et al., 2008) and would therefore benefit more than other groups from reduced pollution. However, there is currently a lack of empirical data on the relationship between the environmental impacts of ETR and the resulting benefits for different social groups. In addition, it is theoretically difficult to link environmental damage in specific places to fiscal instruments that have the general purpose of alleviating pressure on the environment (Meyer-Ohlendorf and Blobel, 2008). In particular, environmentally motivated energy taxes are primarily aimed at combating climate change — an instance where cause and effect are very far from each other in time and place — even if energy use and fossil fuel use in particular also contribute to local pollution ([2]).

There is also no straightforward way of expressing benefits from environmental protection in monetary terms. The OECD (1994) claims that although pollution control benefits tend to be progressively distributed when measured in physical units they may not be when measured in value terms, as lower income households appear to value environmental benefits less than upper income households.

Luhmann et al. (1998) established a qualitative link, at least, between environmental taxation and the distribution of environmental effects. The study estimated the distributional effects of environmental fiscal reform aimed at reducing road traffic emissions in Berlin. It concluded that 'applying tax measures to improve environmental quality associated with the reduction of road traffic may result in a progressive distribution of the benefits and therefore reduce the extent of regressiveness of the distributive function'. As poorer households in Berlin were discovered to be more exposed to road traffic pollution than wealthier households, posing a correspondingly greater health risk for them, a tax would result in a progressive distribution of benefits in terms of health risk reductions.

2.2 Policy options to avoid negative distributional effects

This section discusses policy options to mitigate negative distributional effects or enhance positive social effects of environmental tax reforms. It includes ideas that have actually been applied, as well as suggestions arising in current debate.

The policy options can broadly be structured into two types: measures on the taxation side and measures related to redistribution of revenues. As a third category, there are other complementary measures that are not part of ETR packages but can nevertheless modify their distributional effects.

The distinction between measures inside or outside an ETR package may be more relevant for political communication than in practical terms. All compensation mechanisms normally entail expenditure from the state budget, or foregone tax revenue, whether a formal link to revenue from environmental taxes is drawn or not. A practical difference remains in the case of explicit energy tax revenue redistribution, where the amount of budget resources spent is more directly linked to the amount of energy tax revenue.

Table 2.2 summarises some policy options and Sections 2.2.1 and 2.2.2 provide additional information on them.

2.2.1 Measures on the taxation side

In Germany, certain **energy tax reductions** were introduced specifically for social purposes and not all were sound from an environmental point of view. The environmentally doubtful electricity tax reductions for night storage heating systems (predominantly used in poorer households) were phased out between 2003 and 2007, while a small proportion of energy tax revenue was used to finance modernisation of heating systems. Reduced energy tax rates for public transport, in contrast, can be seen as a subsidy serving both social and environmental objectives.

([2]) In addition, energy taxes may be differentiated according to certain environmental characteristics of the energy carrier other than CO_2. In the case of the German ecotax, for example, a differentiation is made between leaded and unleaded petrol, and according to the sulphur content of fuels.

Table 2.2 Policy options to avoid negative distributional effects of ETR on private households

Taxation side	
Option	**Example/source**
Tax exemptions	Reduced electricity tax for night storage heating (Germany) Energy tax reductions for public transport (Germany)
Progressive taxation (according to energy consumed)	Progressive electricity tax (GBG, 2008) Progressive water/wastewater charges (Portugal)
Tax-free basic amounts of consumption	Electricity tax in the Netherlands
Select a tax base that affects richer households more	Taxes or charges applied on air traffic (Leipprand et al., 2007)
Redistribution side and complementary measures	
Option	**Example/source**
'Eco-bonus' refunds to offset ecotaxes	Swiss CO_2 tax Herlitzius and Schick (2008)
Income tax reductions/income tax reform	Sweden Germany (Bach et al., 2001)
General support measures for vulnerable households (increase in transfer payments)	GBG (2008)
Specific support measures for vulnerable households: transfer payments to cover energy costs	Means-tested benefit for heating costs (Germany)
Specific environment-oriented support measures: subsidies for energy-saving investments, public transport etc.	Subsidies for replacement of night storage heating (Germany) Netherlands until 2003 GBG (2008) Ekins and Dresner (2004) McNally and Mabey (1999)

GBG (2008) proposes a **progressive electricity tax**. For instance, low total amounts of electricity consumption could be taxed at 0.5 ct/kWh, average consumption at 2 ct/kWh, and high consumption at 4 ct/kWh. Moreover, GBG advocates abolishing the electricity base fee and apportioning electricity costs based on price per kWh. These measures would, according to GBG, have positive distributional effects as poor households have lower energy consumption and would therefore profit both from removing the base fee and from a reduced tax rate for low electricity consumption. Concerning the latter measure, however, GBG recognises that the government's influence on the design of electricity provider tariffs would need to be examined.

On tax matters, by contrast, the state has undisputed competency, which underlines the role taxation may have in contributing to more socially equitable pricing of environmental resources. As an example of **progressive environmental charges**, Wier et al. (2005) report that progressive charging in the households sector for water consumption and wastewater treatment is being applied in Portugal.

In the Netherlands, each household is entitled to an **annual tax-free allowance of electricity consumption**. The amount of the allowance is revised annually; in 2008, it was at EUR 199 (Ministry of Finance, 2008). Before 2001, the tax allowance was granted for certain basic amounts of energy use (800 m^3 of gas and 800 kWh of electricity). The allowance was explicitly introduced to mitigate adverse effects of energy taxes on poorer households, recognising that certain amounts of energy use cannot be avoided. In addition, a special tax allowance is granted for older people, bearing in mind that they tend to need more heating energy (VROM, 2004; VROM, 2005).

Leipprand et al. (2008) propose to minimise regressive effects by **taxing goods and services primarily used by high-income groups**. They cite proposals for taxing kerosene or charging airline tickets as one example (an approach that is also supported by the findings by Aasness and Larson, 2002). Referring to the less regressive effect of motor fuels in comparison with household energy, they point out that average figures tend to mask individual hardships.

2.2.2 *Revenue distribution and complementary measures*

Eco-bonuses

Various groups have discussed the concept of the 'eco-bonus' as a means to neutralise the regressive effects of the ecotax (e.g. Herlitzius and Schick, 2008). The concept combines environmental taxes with per-capita refunds, which are distributed across the population. The amount of the eco-bonus is independent from the energy consumption of the individual recipients.

This system is currently practiced in Switzerland, where it has been applied to the national CO_2 tax since 2008 (BAFU, 2011). Here, revenues are distributed proportionally over the population and enterprises based in the country. Taxes paid by enterprises are redistributed to enterprises, with the sum linked to employees' wages. Taxes paid by citizens are shared equally among citizens.

The Swiss canton of Basel City implemented such a bonus system as long ago as 1999. Revenues from a unit-based charge on electricity are redistributed to local residents and domestic industry. Each consumer receives a fixed payment; companies receive a payment for each employee, which increases with wages up to a maximum determined by the contribution ceiling for unemployment insurance (INFRAS, 2003). An earlier Swiss study (INFRAS/ECOPLAN, 1998), which investigated the economic and social impacts of different energy tax schemes, showed that redistributing revenues in the form of a per capita bonus is the most progressive option for ETR and creates the most beneficial social effects, although it leads to slightly negative effects on economic development.

Income tax reductions

Using income tax reductions to ensure more equitable ETR outcomes has already been mentioned in relation to Sweden's 'green tax shift' (Section 2.1.2 above). Similarly, in their comprehensive assessment of ETR effects in Germany, Bach et al. (2001) point out that ETR should be seen as an integral part of a comprehensive reform package, involving reductions in income tax and increases in child allowance. The study modelled the impacts on different social groups of the ETR alone and of the complete reform package. The results suggest that the regressive effects of the ecotax are largely removed when the accompanying changes in income tax are included. Workers and households with children are expected to benefit in particular, whereas the disadvantaged include 'small numbers of singles and couples without children and with low gross incomes' (Bach et al., 2001).

Although this sort of evaluation could be dismissed as somewhat arbitrary, since it mixes environmental policy instruments with non-environmental policies, it may support the conclusion that overall fiscal and social policies can help correct negative distributional impacts from environmental taxes. This may be a better solution than building all correction factors into the environmental policy package itself.

In the German context, Leipprand et al. (2007) mention that social welfare recipients receive a means-tested benefit for heating costs, so that increases in the costs of domestic heating are automatically compensated. Although this institution was created completely independently of the ETR introduction, it can be seen as a measure that alleviates adverse effects on low-income households. However, transfer payments specifically designed to cover energy costs are problematic from both an environmental and a fiscal point of view: they remove the incentive for the recipient to save energy and, by encouraging excess consumption, strain public budgets to an unnecessary extent (Dünnhoff et al., 2006).

Compensation packages

In the UK context, Ekins and Dresner (2004) examined a variety of compensation packages that had been proposed for poor households in the case of introducing a carbon tax on household energy. All proposed compensation packages proved to be progressive on average for the lowest income deciles. However, it must be stressed that the large divergence in energy consumption within the income deciles means that averages conceal big differences in net gains and losses within each. No way was found to ensure that, even with compensation, fuel poverty would not worsen for those already most badly affected.

Consequently, Ekins and Dresner have developed and researched two alternative approaches. The first combines a government-subsidised insulation programme for low-income households with carbon taxes imposed on households only after fuel poverty has been addressed. Although this plan would help reduce social impacts to a small degree, it would not effectively meet the environmental objectives because it still allows for a rise in household carbon emissions for a prolonged period.

The second approach is to promote energy efficiency by imposing a 'climate change surcharge' on households that do not install cost-effective energy-efficiency measures within a specified time. This would be enforced by energy audits of homes beginning with those households best able to afford the measures. Medium- and low-income households unable to pay for these improvements would receive low-cost loans and grants. According to the authors' estimates, implementing such a scheme over ten years would save a minimum of 10 % of household carbon emissions (about 4 million tonnes). At the same time, households would save close to GBP 20 billion at net present value for an initial investment of GBP 6.4 billion. In addition, by contributing to eradicating fuel poverty, the plan would eventually allow for a non-regressive carbon tax to be imposed, which would lead to further emission reductions in the household sector.

Also in the UK context, McNally and Mabey (1999) present the potential results of two options for mitigating the negative effects of energy taxation on fuel-poor households: first, jointly introducing a carbon/energy tax and a lump sum to compensate low-income households for any losses; second, a government-sponsored home insulation programme for low-income families. While the first option would require the government to pay indefinitely for continued inefficient energy consumption, the second encourages conservation and reduces compensation payments, making it more effective in the long run. In the context of motor fuel taxes, McNally and Mabey (1999) suggest that part of the revenue could be used for public transport schemes, especially in rural areas.

In the Netherlands, until 2003, around 15 % of the revenue from the tax on household energy was used for an energy premium system rewarding private households for the purchase of energy-efficient appliances (Duscha et al., 2005).

Finally, GBG (2008) proposes an ecotax redistribution scheme for Germany combining various concepts. One-third of the revenues would be used to subsidise investments in energy-efficient equipment, such as refrigerators (the 'climate bonus'). Another third would be divided among recipients of transfer payments to compensate for rising energy prices (the 'social bonus'). These steps would mean that the incentive for energy saving would not be reduced. The last third would be divided among social insurance contributors and be disbursed to enterprises on a per-employee basis (the 'employment bonus'). According to GBG, this scheme would result in higher employment effects than a blanket decrease of non-wage labour costs.

Wier et al. (2005) report that in Denmark the Ministry of Taxation considered that 'personal green allowances' would create too high an administrative burden and therefore preferred **compensation through reductions in other taxes**. However, the same authors sound a note of caution with regard to this approach. First, they observe that this solution may work better in countries like Denmark, with high overall taxation and a broad array of tax bases, than in countries with different taxation policies. Second, they warn that where there is only a weak link between environmental taxation and compensation measures applied in other areas, those compensation measures may not counteract the general perception that environmental taxes are socially unfair.

2.3 Conclusions and issues for further analysis

It has been clearly demonstrated for most of the European countries examined that environmental taxes often have regressive effects on private households. The actual distributional impact depends, among other things, on the object of taxation. Taxes on household energy tend to be clearly regressive, while transport-related taxes have mixed distributional results. And although these regressive effects may be mitigated by various redistribution and compensation mechanisms, they often remain to some extent.

In the case of energy taxes — which have been by far the most commonly applied taxes in ETR – there is likely to be limited political scope for further increasing the tax burden. Although energy prices fell during the recent economic slump in Western economies, resource scarcity and supply bottlenecks are likely to lead to new price rises in the foreseeable future. In the past, fuel tax increases coinciding with high oil prices have led to massive protests and policy changes (e.g. in the United Kingdom and Germany). Moreover, in the area of household energy in Germany, hardships imposed on poor households by high energy costs have recently become a subject of intensive debate. It has been estimated that each year around 800 000 households in Germany are temporarily cut off the electricity grid because they are unable to pay their bills (Meyer-Ohlendorf and Blobel, 2008).

At the same time, energy taxes tend to have a price-stabilising effect as their amount is not affected by the price volatility of energy and carbon markets. They therefore help provide a long-term price signal to induce behavioural change and investments. VAT, in contrast, exacerbates price fluctuations, as it is applied as a percentage of price, not in relation to physical units.

Keeping the prices for energy and other environmental resources low cannot be considered an appropriate way of achieving social policy objectives. Instead, measures should be designed to improve the situation of poor households while keeping the incentive to save energy and other resources. This can be achieved, for example by adjusting other elements of the taxation system (e.g. income and labour taxation) in a way that contributes to a more even distribution of income, or by increasing overall transfer payments for the poor.

Economic instruments of environmental policy must be implemented and communicated in a way that takes social considerations into account very carefully. In particular, all parts of the population, even the poorest, must be able to meet their basic needs that depend on natural resources. This is currently not the case, even in rich western European countries (as exemplified by excess winter mortality associated with fuel poverty in the United Kingdom, as well as by the incidence of poor households being cut off the power grid in Germany). Rather than making energy cheap across the board, policies should aim to ensure certain minimum standards of access to energy and transport services for the whole population.

In order to enhance social acceptance and the environmental effectiveness of ecotaxes, it is recommendable to spend part of the revenue on environmentally friendly investments, e.g. providing support schemes for purchasing energy-efficient appliances or financial incentives to improve the housing stock through insulation. This enhances the capacity of those taxed to adjust their consumption behaviour, contributes to environmental restructuring of the economy and creates employment. It is also very much in line with proposals for a 'green new deal' in response to the economic slump in many advanced economies.

In view of the ability of ecotaxes to incentivise environment-friendly behaviour, as well as the notion of 'environmental justice', it should be noted that empirical analysis has shown a higher per-capita use of environmental resources by high income groups, while poorer segments of society, due to their lower levels of consumption, cause less harm to the environment (Pye et al., 2008). While there is limited scope for avoiding or substituting certain basic levels of resource use even if prices are high, excess consumption by high income groups is not very effectively targeted by ecotaxes as long as the charges remain low in proportion to income. This provides arguments for granting tax allowances for certain basic amounts of consumption, introducing progressive forms of excise taxes (c.f. Ott and Schlüns, 2008), or shifting the tax base to goods that are especially consumed by high-income groups.

On the revenue redistribution side, the 'eco-bonus' concept has been found to neutralise regressive impacts effectively. However, automatic redistribution reduces the function of ecotaxes to steering environmental incentives, while completely forsaking their revenue-raising function. It would also mean giving up the 'double dividend' of also generating employment by lowering labour costs.

In the German context, proponents of the 'eco-bonus' have argued that while ETR as currently implemented has been perceived as socially unbalanced, a per-capita redistribution would gain more popular support. However, there may be some reasons to doubt this argument. Opinion polls have shown that the redistribution aspect of current ETR is very poorly understood by a large majority of the population. First, they are personally much more aware of the taxation burden element than the redistribution side. Second, to the extent that the redistribution concept is known, it is often considered inconsistent as people believe that revenues should be spent on securing environmental objectives (Beuermann and Santarius, 2002). This suggests that it is far from guaranteed that the eco-bonus concept would be better understood.

3 Distributional impacts of ETR in the EU: a scenario study

When analysing the political feasibility of an ETR package, it is essential to consider the distributional implications. It is therefore highly important for policymakers to understand a package's impacts on the income distribution across individuals and households. If the effects are considered regressive then it may be desirable to apply exemptions or offer other financial assistance to protect the most vulnerable groups in society.

There is clearly scope to expand the knowledge base in this area. Recent scenario studies of ETR impacts, such as the Anglo-German Foundation (AGF)-funded 'petre' project 'Resource productivity, environmental tax reform and sustainable growth in Europe' or the EC-funded 'Competitiveness effects of environmental tax reforms' (COMETR) (NERI et al., 2007), have given little attention to equity issues. With this in mind, this chapter analyses the distributional implications of a broad-based ETR for households, disaggregated by income, employment status and location. The scenarios are the same as those used in the petre project so build on the aggregate results presented in Pollitt and Chewpreecha (2009) and Ekins and Speck (2011).

As noted at the start of Chapter 2, fully evaluating the distributional impacts of ETR for households requires assessment of four sets of impacts:

- **Direct consequences of the increased environmental taxes** for each socio-economic group. These consequences are related to the expenditures by the different groups on the goods and services that are taxed. The central problem is that excise taxes have often been found to have a regressive effect, i.e. poorer population groups pay a larger proportion of their income than richer population groups. Chapter 4 of this report presents a case study for Germany, carried out using the Gesellschaft für Wirtschaftliche Strukturforschung (GWS) PANTA RHEI model, which also takes into account how these expenditures change in response to environmental taxes.
- **Direct consequences for these socio-economic groups from recycling environmental tax revenues** by reducing taxation of labour (both employer contributions and income tax). The concept of an ETR includes both imposing taxes on environmentally harmful activities and redistributing the revenues levied.
- Other effects are not of a directly financial nature but arise from the **broader economic impacts of ETR.** These include macroeconomic effects such as impacts on employment. ETR will change relative prices throughout the economy and these will have varying effects on different groups. E3ME models these changes through input-output relationships and sectoral rates of cost transferral.
- **Environmental effects of the ETR** on different socio-economic groups. There is now substantial evidence (see Chapter 2) that, as might be expected, lower income groups generally experience lower environmental quality than higher income groups. To the extent that ETR improves environmental quality (which of course is one of its principal objectives), it is likely that these environmental benefits will be differentially distributed among households.

Finally, ETR design may include **exemptions and other provisions to help achieve economic, social or environmental goals**. These can be seen as part of the first two sets of effects listed above but should be addressed separately because they constitute deviations from the basic ETR design.

The first three of these elements were assessed using the E3ME model. While clearly important, the fourth issue is much more difficult to quantify and requires a more specialised environmental modelling approach that is beyond the remit of this study.

Section 3.1 of this chapter provides a general outline of the E3ME model, followed by a detailed description of the method used to model the impact of the ETR on income distribution. Section 3.2 introduces the baseline case and the scenarios, Section 3.3 sets out the results from the modelling exercise and Section 3.4 presents the conclusions.

3.1 Model overview

At the European level, an assessment of the distributional impacts of ETR was carried out using the Cambridge Econometrics European model 'E3ME' (3). The E3ME model includes 13 different socio-economic groups, including five income quintiles, six groups defined by employment status (including retired) and urban and rural splits.

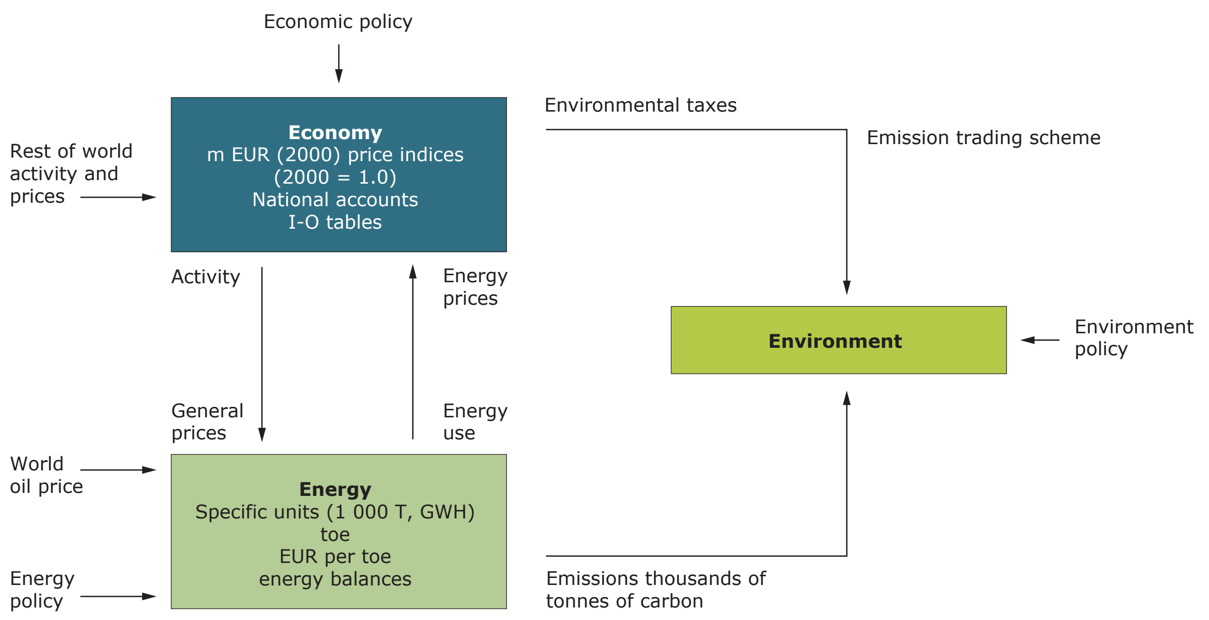
E3ME is a large-scale model of Europe's economies, energy systems and environment. A key feature of the model is its high level of disaggregation, which allows for analysis of detailed policy measures and enables the model to produce a thorough set of results. The main model specifications in version 4.6 of E3ME are:

- 29 countries (the EU-27 plus Norway and Switzerland);
- 19 energy-using groups;
- 12 fuels;
- 42 economic sectors;
- 41 household spending categories.

3.1.1 Energy-environment-economy interactions

E3ME aims to meet an expressed need of researchers and policymakers for a framework for analysing the short- and long-term implications of energy-environment-economy (E3) policies. The model incorporates two-way linkages with feedback effects between the economy, energy demand and supply, and environmental emissions (see Figure 3.1). These linkages are a clear advantage over many other models, which may either ignore the interaction completely or only assume a one-way causation, leading to a bias in results.

Figure 3.1 E3ME as an E3 Model



(3) For more comprehensive information regarding the E3ME model, see the E3ME website (www.e3me.com) and the online technical manual: www.camecon-e3manual.com.

Version 4.6 of the model also includes a submodel of materials consumption, which is required to assess the impacts of the materials tax in the scenarios. Its structure is similar to that of the energy submodel, with two-way links to the economy. It is described in more detail in Pollitt (2008).

3.1.2 *The economics of E3ME*

The economic structure of E3ME is fully consistent with the structure of national accounts, as defined by ESA95 (Eurostat, 1995), and the definitions used by Eurostat. Sectors are linked through input-output tables, while countries are linked through trade and currency flows.

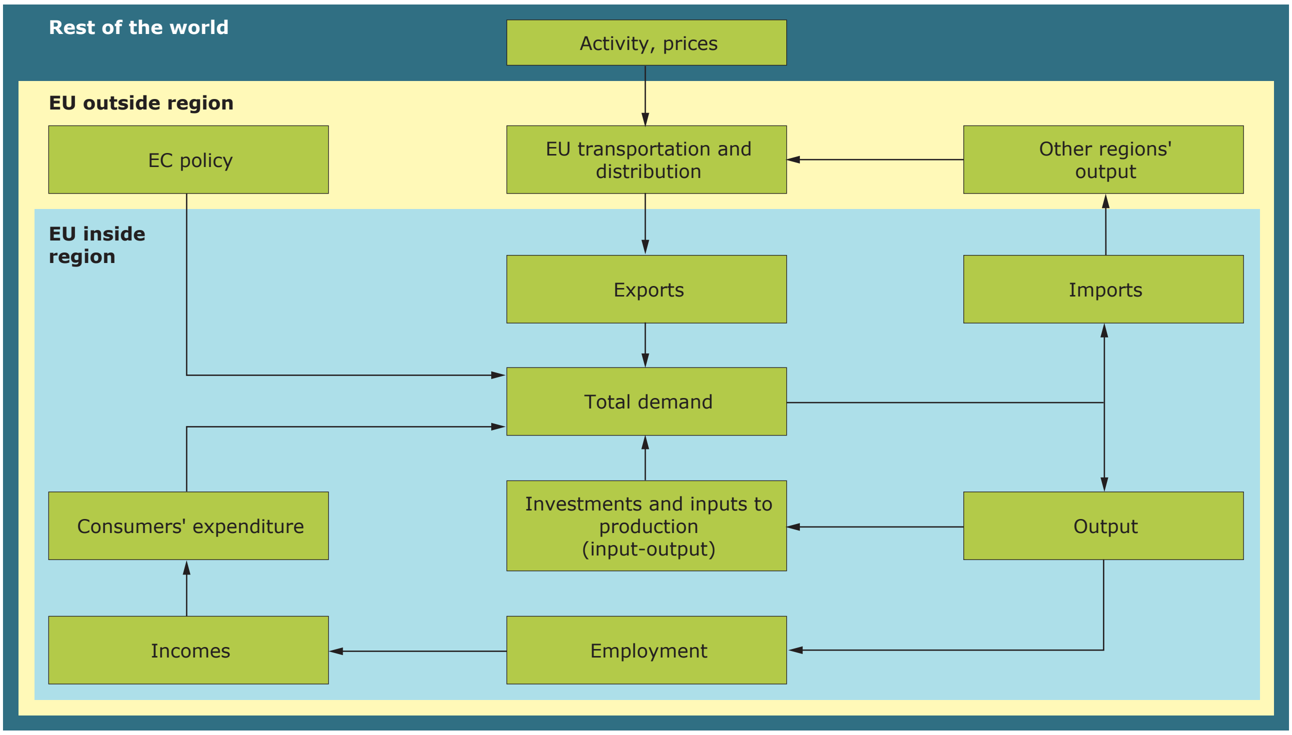
Figure 3.2 shows how the economic module is solved as an integrated EU regional model. Most of the economic variables shown in the chart are at a 42-industry level. The whole system is solved simultaneously for all the industries and all 29 regions, although single-region solutions are also possible. Figure 3.2 shows interactions at three spatial levels: the outermost area is the rest of the world; the next level is the European Union outside the country in question; and, finally, the inside level contains the relationships within the country. It also shows three loops or circuits of economic interdependence: the export loop, the output-investment loop and the income loop.

3.1.3 *Econometric specification*

Within the structure of the national accounts, E3ME contains around 30 stochastic sets of equations with behavioural parameters estimated using econometric techniques. These equation sets cover the components of final demand, prices and the labour market, plus energy and material demands. Each equation set is disaggregated by sector and by region. For example there are 42 x 29 equations in the set for employment.

Equation parameters are estimated independently for each of these equations, with no cross-sectional or cross-regional restrictions (i.e. no panel data techniques) imposed on the estimation. The exception to this is the newer Member States with data series starting in 1993 or later, where it is not appropriate to estimate long-run relationships on data from a period of transition. For these countries, long-run parameter coefficients are set to match EU-15 averages using a shrinkage technique (Spicer and Reade, 2005).

Figure 3.2 E3ME as a regional econometric input-output model



The method of estimation is based on the theories of cointegration and error correction (see Engle and Granger, 1987; Hendry et al., 1984). Essentially this is a two-step method of estimation that allows for short-term dynamic effects, moving towards a long-term outcome (often regarded as equilibrium) and the model is able to capture transition effects as well as longer-term impacts.

Due to the simultaneous nature of many of the model's relationships (for example prices and quantities), the estimation technique used is instrumental variables. The instruments used are based on the previous year's data.

The software used to carry out the parameter estimates is based on the Ox programming language (see Doornik, 2007).

3.1.4 *Modelling the impact of ETR on income distribution*

The ETR modelled in this study can be summarised as:

- imposing a tax on energy and material inputs;
- delivering a corresponding reduction in employers' social security contributions and income taxes.

The analysis of the distributional implications of the ETR for households was carried out using a scenario-based approach. The scenarios in the project are ex-ante, meaning that they provide an assessment of future developments under different sets of inputs. In order to interpret the effects of the different inputs, a separate model run, referred to as a baseline or business-as-usual case, with no additional inputs, is provided.

The baseline and ETR scenarios used here were based on those in the petre project. As a result, the distributional findings in this study are consistent with the more macro-level results presented in petre. The exact specifications of the scenarios and the baseline case are discussed in detail in Section 3.2.

E3ME, as currently specified, has a relatively simple top-down, partial model treatment of the impact of ETR on different socio-economic groups. This treatment shares some of the characteristics of micro-simulation models, described in detail in an earlier application of E3ME to ETR and its effects on equity (Barker and Köhler, 1998). That study relied on data from 1988, 1992 and 1993, however, and was restricted to eleven EU Member States. Contrastingly, version 4.6 of E3ME makes use of household spending survey data for 2005 published by Eurostat in spring 2008, and covers all EU-27 Member States individually. The model also includes 13 different socio-economic groups, including five income quintiles, six groups defined by employment status (including the retired) and urban and rural splits.

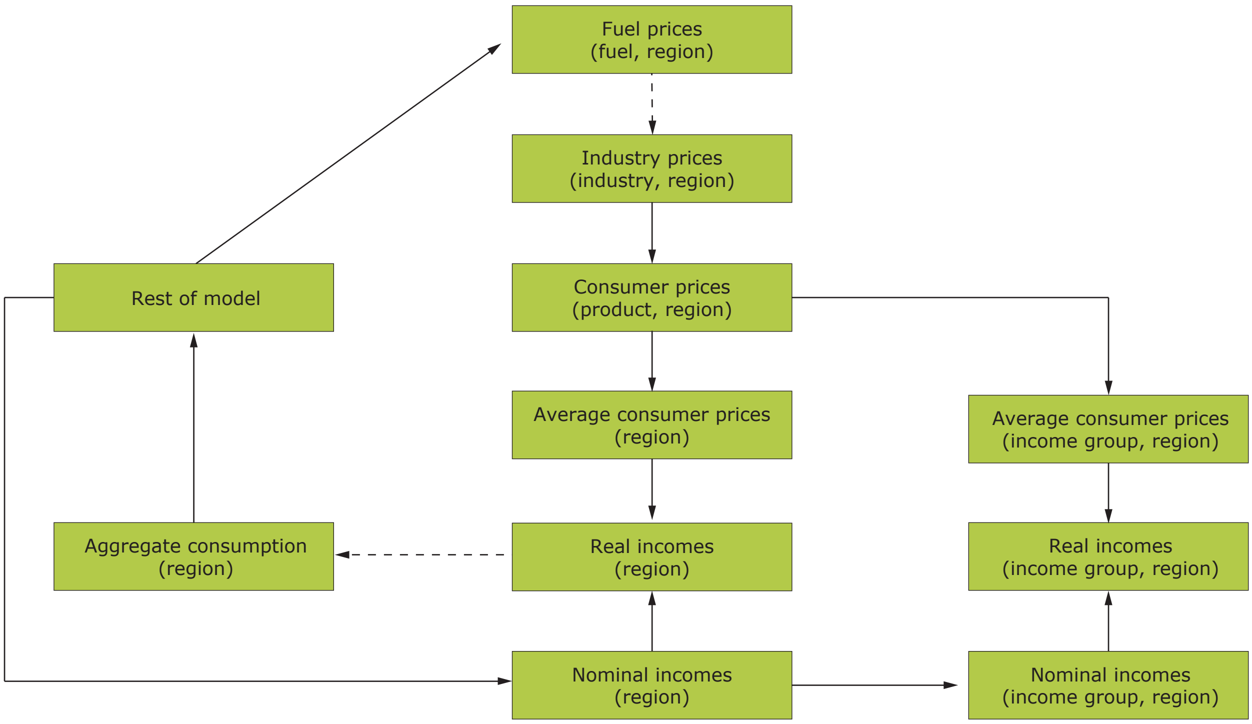
The line of causation in the model is as follows:

- Changes in fuel prices due to ETR will affect industry prices (disaggregated by industry and region). Industry prices are also indirectly affected by other factors in the model, such as wage demands.
- A change in industry prices will subsequently affect consumer prices (disaggregated by consumption category and by region). An average consumer price for each region is calculated by taking a weighted average of the disaggregated consumer prices.
- Nominal incomes (which may be disaggregated only by region or by region and socio-economic group) comprise total wage receipts plus other income such as dividends. Real incomes (disaggregated by region but not by socio-economic group) are calculated by dividing total nominal incomes (disaggregated only by region) by average consumer prices. This is a key factor in determining long-term growth in household consumption.
- Once these variables have been estimated, average consumer prices (disaggregated by socio-economic group and region) are estimated by taking a weighted average of consumer prices, but with a different set of weights for each group and region.
- Real incomes (disaggregated by socio-economic group and region) are then calculated by dividing nominal incomes (disaggregated by region and socio-economic group) by average consumer prices in each group.

It should be noted that this top-down treatment has no feedback (either direct or indirect) from the income distribution variables to the rest of the model, including determination of aggregate household consumption. This is regarded as an acceptable simplification for the purposes of the present study, which is analysing the effects of energy prices on income distribution. If the focus were on the distributional effects in terms of fuel use then it would not be an appropriate method.

Although real incomes are estimated for each socio-economic group, the model relies on the

Figure 3.3 Model structure: distributional impacts



Note: A solid line represents a general or identity relationship, a dotted line one that is explicitly estimated using historical time-series data.

simplifying assumption that the consumption function is identical for all groups. This is because the time-series data required for estimating separate consumption functions for each socio-economic group are not available at the European level or, in most cases, at the national level. Germany is an exception and is therefore the focus of a separate analysis in Chapter 4.

Figure 3.3 illustrates the relationships between key model components, with feedback coming from the aggregate consumption equations but not from the income distribution analysis. The indirect effects follow from changes to variables calculated in the rest of the model.

Revenue recycling will have further impacts. Reductions in employers' social security contributions will shift people from unemployment to employment (i.e. between socio-economic groups) but are not expected to change the incomes within groups. Reductions in income tax, however, will boost the incomes of all groups where wages make up a share of total income. Nominal incomes (at the bottom of Figure 3.3) will therefore increase.

3.2 Baseline and scenarios

3.2.1 *Baseline forecast*

The role of the baseline

The scenarios in the project are ex-ante, meaning that they provide an assessment of future developments under different sets of inputs. In order that the effects of the different inputs can be interpreted, a scenario with no additional inputs is provided. This is referred to as the baseline or business-as-usual (BAU) case. Results from the other scenarios are reported in terms of the difference from the base (usually as a percentage), allowing easy interpretation of the impacts of the scenario inputs.

The baseline itself is not part of the analysis but it is important for presentational purposes and should not be regarded as a forecast of the most likely outcomes. As most of the model's relationships are log-linear and the results are presented as percentage differences from the base, the levels in the baseline do not usually affect the final results. For example, if the model suggests that a 50 % increase in petrol prices leads to a 10 % fall in demand, the results will report a 10 % fall, whether the baseline price is 75 cents per litre or 150. However, there are cases where this rule does not hold. These are usually instances where the model's relationships are not log-linear, such as when they are simple linear functions, for example:

- unemployment is the difference between labour supply and labour demand;
- GDP is the sum of its components;
- total energy prices are the sum of the raw inputs plus excise duties and other energy taxes.

The last point is particularly relevant to the scenarios presented here, as they include taxes on energy products. Effectively this means that the relative impact of the energy taxes is dependent on the baseline energy prices. For example, if the price of petrol is EUR 1 per litre, a 20 cent/litre tax would mean a 20 % increase in prices. However, if the baseline price is EUR 2/litre then the increase would be only 10 %.

Clearly there is a high level of uncertainty over the development of future international energy prices, so for this analysis an alternative baseline was provided with higher prices (described in more detail below). However, the scenarios were designed and assessed before the collapse of Lehman Brothers in September 2008 so the financial crisis and the consequent effects on the world economy have not been incorporated into the analysis.

The baseline also plays an important role in determining the scenario results when fixed targets are met. In this study's scenarios, GHG emissions are reduced by 20 % compared to 1990 levels. This target becomes more difficult to meet if the BAU case includes a 10 % increase in emissions than if it suggests there is already a 10 % reduction.

The conclusion from this is that the baseline can play a role in determining the aggregate results from the scenarios and it is therefore important that a robust and credible baseline is used. However, the baseline does not have any particular impacts on the distributional outcomes from the modelling.

Source of the baseline

One option for generating the baseline would be to create a forecast using E3ME. This would ensure a degree of consistency in all the variables — particularly between Europe's economies and energy systems — as it would be produced by the model's own internal structure, based on the system of national accounts. However, this would be a major exercise as there are numerous model variables to take into account and each output would have to be checked and verified.

An existing forecast was therefore used to provide the baseline. E3ME's current baseline solution is calibrated to match the projections in European Commission's report 'Energy and transport: trends to 2030' (DG TREN, 2008). That forecast is based on the PRIMES (E3M-Lab, 2005) model, which delivers detailed energy results. As it results from a modelling exercise, the forecast is consistent across EU Member States and in terms of the projections of economic development, energy demand and CO_2 emissions — a requirement for use with E3ME. The forecast, along with its underlying assumptions, is published on the European Commission (DG TREN) website. E3ME's input assumptions, including international energy prices, are set to match.

Further processing

Several further steps were needed before the forecast in DG TREN (2008) could be used with E3ME:

- annual results were estimated, using a simple interpolation algorithm;
- sectoral output was estimated in a manner consistent with the published aggregate totals;
- economic variables not included in the baseline were estimated in a consistent manner.

Economic variables were estimated by matching growth rates to a similar variable, for example gross output growth was set at the same rate as net output growth. The employment forecast was set to match the one published by the European Centre for the Development of Vocational Training (CEDEFOP) (Wilson et al., 2007), which was generated using E3ME and is based on the same baseline economic forecast.

The DG TREN (2008) baseline covers the period up to 2030 and in E3ME has been extrapolated up to 2050. However, these scenarios are only run in the period up to 2020, as this year represents the EU's targets on emission reduction and also the end of Phase III of the EU emission trading scheme (ETS).

The E3ME baseline and scenario results were made consistent with the DG TREN baseline using an internal scaling mechanism. Further information is available in the E3ME model manual (Cambridge Econometrics, 2011).

High oil prices

Oil prices reached a record high of USD 146 per barrel (pb) in mid-2008. This price is significantly different from the forecast prices used in the DG TREN baseline (some USD 60 pb in 2010 prices). Prices have since fallen sharply in response to the global financial and economic crisis to around USD 70 pb in September 2009. It is clear, however, that there is a lot of uncertainty about future oil prices; for example would a global economic recovery necessarily be accompanied by a return to high oil prices?

The literature (e.g. Longo et al., 2007; Chevillon and Rifflart, 2007) produces a wide range of possible outcomes for energy prices so cannot provide much help in providing a reliable answer to this question. The solution that was adopted in this study was therefore to run an additional alternative baseline, which features higher oil prices. This baseline is an endogenous solution of E3ME, with all inputs the same as the main baseline other than the input energy prices. The values for energy demand and economic growth are determined by E3ME's own estimated parameters (i.e. it is solved as if it were a scenario). The main scenario is also run with both sets of oil prices so that the results can be viewed as a difference from base in a situation with moderate prices and with high prices. A range of possible outcomes is therefore given.

3.2.2 The scenarios

The scenarios evaluate the economic and social effects of ETR with a particular focus on productivity and competitiveness. The four scenarios are designed to highlight these impacts under different sets of background assumptions. The ETR which forms the main scenario (LS1) is described first, and then the variants are outlined.

Each scenario is identified by a three character acronym. The first letter indicates the baseline to which it is compared, with L and H indicating the baseline with the lower international energy prices and the baseline with the higher prices respectively. These scenarios are identical to those used in the petre study.

LS1

The LS1 scenario can be summarised as follows:

- the EU meets its 2020 GHG reduction targets;
- a tax is imposed on material inputs;
- a corresponding reduction is applied to income taxes and employers' social security contributions.

Emission reductions

E3ME includes all six greenhouse gases, as defined by the Kyoto Protocol, in its treatment of emissions. Its treatment of non-energy, non-CO_2 emissions is relatively simple, however, so the GHG targets were translated into CO_2 ones because this was not judged to affect the results of the study materially. This meant that the target was – 15 % in 2020 compared to 1990 levels.

When the analysis was carried out, the European Commission had not yet suggested how this target should be met, beyond a basic ETS and non-ETS share, so the model assumes a single price instrument that is applied equally to all sectors (including those inside and outside the ETS). Effectively this means that the non-traded sectors face a carbon tax equal to the ETS price, with the number of ETS allowances being continuously adjusted until the targets are met. The carbon tax is additional to any existing taxes. The carbon tax is put in place in 2010 but the revisions to ETS allowances do not start until 2013 to reflect the Phase II agreements that already exist.

Aviation is included in the ETS over 2012–2013, as was expected, and there is an assumed shift to auctioning of allowances in Phase III, with power generation having to purchase all of its allowances and the share of auctioning being stepped up gradually to 100 % in 2020 for the other ETS sectors.

All action is assumed to be through domestic effort, with Joint Implementation and Clean Development Mechanism payments, permissible under the Kyoto Protocol, excluded from the modelling.

Materials tax

The materials tax covers a range of biomass and mineral materials consistent with Eurostat totals, apart from energy products. Biomass and minerals are included in the tax. Materials taxes are additional to any existing taxes and are set at a rate that increases the input costs of materials by 5 % in 2010, rising gradually to 15 % in 2020 ([4]).

Revenue recycling

In line with the definition of ETR (see Section 1.1), the reforms are assumed to be directly revenue neutral. As such, increased revenues from environmental taxes are matched by the reductions in other taxes. It should be noted, however, that there could be indirect effects on governments' balances through secondary effects, for example reductions in revenues from existing fuel excise duties.

Since the carbon tax affects both businesses and households via higher energy costs, the revenues are allocated to both employers and households. The split is calculated using E3ME's fuel-user classification. The revenues from carbon taxes paid by households are used to reduce income taxes, while those from all other sectors are used to reduce employers' social-security contributions. The exception is road transport, where both businesses (e.g. hauliers) and households (mainly private cars) pay for fuel. Since the data do not discriminate between business and domestic purchases of transport fuels a stylised assumption is applied, with revenues in this sector split equally between reductions in income taxes and employers' taxes.

The materials taxes mostly fall on business, so the revenues are recycled through lower employers' social-security contributions.

Other scenarios

As outlined below, the other scenarios represent small changes in specification from LS1, allowing the modelling to address some of the key issues of environmental taxation. All of the scenarios are summarised in Table 3.1.

HS1

HS1 is identical in design to LS1, except that it is assumes higher international energy prices. This partly reflects a high level of volatility in oil prices in the period when the analysis was carried out, but also demonstrates the sensitivity of results to a key input assumption.

In HS1, world oil prices are USD 113 pb in 2010, rather than USD 60 pb in the baseline and LS1 (both at nominal prices). The same growth rates are used thereafter. Results from this scenario should be compared to the alternative baseline (which has the same energy prices) but also give an interesting comparison with LS1. For example, a lower carbon price is required to meet the emission-reduction targets in HS1 than is required in LS1.

Following a common modelling assumption, the prices of non-oil energy inputs are set to grow at the same rate as the headline oil price. This makes results easier to interpret (as direct effects may otherwise be obscured by fuel switching) but also reflects the fact that gas contracts are often linked to oil prices and that transportation costs make up a large share of coal prices.

HS2

HS2 is identical to HS1 except that the revenue-recycling mechanisms are adjusted. The same split between income and employers' taxes is estimated but 10 % of the total revenues are directed towards eco-innovation.

Many studies have attempted to define 'eco-industries' (e.g. Jänicke and Zieschank, 2008; GHK et al., 2007) but these are usually much too detailed to fit into E3ME's framework, or available national accounts data. Therefore, for the modelling, the revenues were split evenly three ways, between:

- subsidies for renewable electricity generation;
- investment in efficient household appliances;
- investment in efficient transport equipment.

These directly feed into the model's energy-demand sub-model. The investment in renewables feeds into the model's energy technology model (see Anderson and Winne, 2004; Barker et al., 2007). The take-up of more efficient machinery and vehicles can

([4]) Data for materials prices are not generally available at the broad level used in E3ME, so an implicit calculation is used instead, with prices rising by a percentage rather than by a fixed amount per tonne.

lead to more efficient energy use in all sectors but particularly affects transport sectors and firms that use heavy machinery.

The aim of this scenario is to demonstrate that the carbon price required to meet the emission-reduction targets will not be as high as in HS1 because there are simultaneous increases in energy efficiency. This means that the same reductions are achieved at a lower cost.

HS3

The final scenario considers the effects of ETR in the context of international cooperation. In this scenario the GHG emission-reduction target is 30 % rather than 20 % (and the corresponding CO_2 target 25 % rather than 15 %), all achieved via reductions in domestic emissions. However, the competitiveness effects are less due to higher import prices as the rest of the world engages in similar action.

This scenario corresponds to the EU's agreement to deliver higher domestic cuts in emissions if the rest of the world were to take action as well. All other inputs remain the same as the baseline and E3ME is solved to meet the higher reduction targets.

3.3 Results

3.3.1 Main findings

The aim of this study was to assess the distributional effects of ETR on household income using data from the Eurostat household expenditure survey (2005).

Thirteen different socio-economic groups were considered in the study, specifically:

- five income quintiles;
- six groups defined by employment status (including retired);
- urban and rural splits.

Real incomes are formed by the combination of nominal incomes and price (inflationary effects), both of which are affected by the scenarios used in the study. In E3ME, incomes are composed of:

- wages;
- non-pension benefits;
- pensions;
- other income (eg dividends).

Income taxes and employees' social security contributions are subtracted from this to give a measure of real disposable (i.e. 'take-home') income. The composition of each group's disposable income varies (for example the retired group are heavily dependent on pensions). However, in the petre scenarios, benefits and pensions were index-linked to wages, so gross income in each group tends to grow by the same amount ([5]). There is, however, variation in income tax rates.

Following from the petre results, there are increases in real incomes in all the groups in all of the scenarios in 2020 at the EU level (see Table 3.2). This increase is in the region of 1.5 % in the scenarios with higher carbon prices (in LS1 due to lower oil prices and in HS3 due to a higher carbon-reduction target) where there are larger sums of revenue available for recycling. The increases are up to 1 % in the other scenarios.

Table 3.1 Summary of scenarios

	LS1	HS1	HS2	HS3
Energy prices	Baseline	High	High	High
CO_2 reduction	– 15 %	– 15 %	– 15 %	– 25 %
Materials tax	15 %	15 %	15 %	15 %
Revenue recycling	Employment taxes and income taxes	Employment taxes and income taxes	Low-carbon investment, employment taxes and income taxes	Employment taxes and income taxes
Other				International cooperation

Note(s): CO_2 reduction is in 2020 compared to 1990 levels. Materials tax is share of price in 2020. See main text for more detail.

([5]) This is an important assumption because if benefits are indexed to general prices then groups relying on benefits would gain by less. If benefits are fixed in nominal terms the outcomes would most likely be negative.

Table 3.2 Change in real income — EU results, 2020

	LS1	HS1	HS2	HS3
All households	1.46	0.62	0.95	1.58
Expenditure groups				
First quintile	1.51	0.63	0.87	1.70
Second quintile	1.43	0.62	0.92	1.59
Third quintile	1.38	0.60	0.92	1.51
Fourth quintile	1.44	0.63	0.96	1.57
Fifth quintile	1.56	0.68	1.03	1.67
Socio-economic groups				
Manual workers	1.40	0.61	0.95	1.52
Non-manual workers	1.41	0.63	0.98	1.52
Self-employed	1.31	0.58	0.95	1.41
Unemployed	0.79	0.41	0.65	1.03
Retired	1.06	0.49	0.75	1.28
Inactive	0.14	0.13	0.34	0.36
Population density				
Urban	1.60	0.70	1.00	1.75
Rural	1.31	0.57	0.89	1.44

Note: The data represent the percentage deviation of real incomes from the appropriate baseline (i.e. L or H) in each group in 2020 for the EU-27 as a whole.

Statistical discrepancies matching national accounts and survey data mean that the aggregate results for the socio-economic groups do not always correspond to the data for 'all households'.

Source: E3ME, Cambridge Econometrics.

It is important to note that these results are averages for each group. This is as detailed as the survey data go but there may be considerable variation within groups. For example, within one group, different individuals may have more or less efficient central heating systems installed or there may be differences in the level of insulation in their homes. Car ownership within groups may also vary and the size and fuel efficiency of cars may differ, affecting the amount of income that is spent on them. A final point to note is that, depending on whether individuals are on fixed or flexible contracts, the impacts on nominal wages will vary in response to higher inflation rates. Those workers who are on flexible contracts are not tied in for long periods of time so have far more bargaining opportunities than those on fixed contracts, and hence may see larger increases in their real incomes.

Sections 3.3.2–3.3.4 interpret the results in each category, i.e. across the expenditure groups, the socio-economic groups and the population density alternatives. The possible reasons for the differences across groups were discussed in Section 3.1.4, and the results are generally consistent with that analysis.

3.3.2 *Expenditure groups*

Several general trends can be identified within the different scenarios. First, perhaps unexpectedly it is not the lowest-income groups that lose out relative to the other groups. In fact the middle income quintiles secure the lowest rise in real incomes. The reason for this is that they spend a larger share of their incomes on heating and transport fuels combined, while the lower-income households do not tend to own cars (and the high-income households spend relatively less on fuel).

The exception to this is HS2, where the lowest income group is the one that gains the least and the ETR is slightly regressive across all the income groups. The main reason is that a share of the revenue is recycled into investment in low-carbon technologies, leading to larger gains in vehicle efficiency. This disproportionately benefits the higher-income groups who spend more on transport fuel.

3.3.3 *Socio-economic groups*

The trends within the socio-economic employment groups are clearer. In all scenarios the unemployed and the inactive groups experience the smallest increases in real incomes, whilst the retired also benefit less than other working groups. This result occurs because these groups do not gain anything from lower income tax rates. On the other hand, manual and non-manual workers and the self-employed experience larger increases in real income, with HS3 again producing the greatest changes for all groups.

Manual and non-manual workers see similar increases in their real incomes, whereas the self-employed experience slightly less of an increase. This could be due to the effect that higher energy prices might have on business profitability and hence dividends, especially if they cannot completely pass these costs on via increased prices.

3.3.4 *Population density*

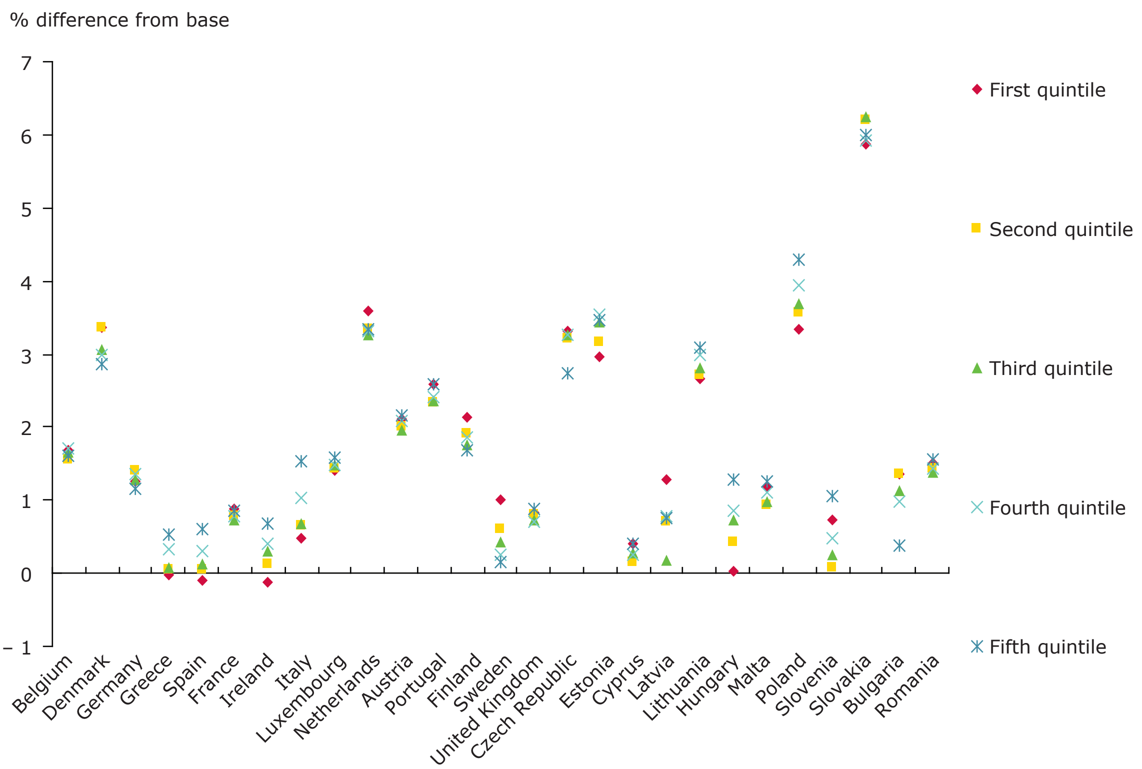
The results show that urban households see a larger increase in real incomes than rural households in all scenarios. Living in a rural area often means that fuel consumption is higher due to the need to drive further and more frequently to reach amenities, workplaces, schools and so on. Those living in cities may infrequently use their cars or not own a car at all if it is more feasible to walk, cycle or use public transport. Furthermore, rural households often spend more on heating their homes, due to older, poorer central heating systems or insulation. Rural homes are also larger and more detached on average than urban dwellings, further increasing heating expenditure.

The smallest difference in the change in real incomes between urban and rural households exists in scenario S2H, reflecting the advantages that revenue recycling for investment in low-carbon technologies would bring to rural households, through improvements in heating systems and, in particular, vehicle fuel efficiency.

3.3.5 *Variation between Member States*

When considering each individual Member State separately, the results for LS1 [6] show that there is considerable variation in the changes in income

Figure 3.4 National changes in household income by quintile, LS1, 2020



([6]) LS1 was chosen because it has some of the biggest changes. However, the broad conclusions would be the same whichever scenario was considered.

between countries. These results are presented in Figure 3.4. It is evident that there are much larger differences in income changes between countries than within countries. While the changes in income are usually fairly similar for each income group within one country, the differences between countries are often large. For instance, whereas all income quintiles within the United Kingdom experience changes in income of around 1 %, in Slovakia the changes in income are all around 6.5 %.

There are several reasons for the variation in income changes:

- different macroeconomic outcomes in the scenarios;
- different patterns of income sources;
- different expenditure patterns in each group.

In almost all cases there are increases in real incomes. However, it should also be noted that in Greece, Spain, Ireland and Hungary a fall or no change in real incomes is reported in one of the income groups. These results always occur in the lowest income quintile, mainly because individuals within these groups do not have to pay a large amount of income tax but do spend a large proportion of their income on energy for heating. In these cases the reductions in income tax do not outweigh the negative effects of higher energy prices.

In these particular countries it is also often the case that the groups are rather spread out in terms of their gains in real incomes, with the highest income group experiencing the largest increase in their real incomes. This suggests that income distribution becomes more unequal due to ETR. For example, in Hungary, the lowest income quintile sees no increase in real incomes, yet the highest income group enjoys an increase of around 1.5 %.

3.4 Conclusions

3.4.1 Modelling environmental tax reform

The modelling results showed that, at the aggregated EU level, the ETR would generally create a positive change in real incomes for all socio-economic groups. However, the results show that the different socio-economic groups may gain by different amounts according to their income status, their employment status or whether they live in an urban or rural area.

First, those groups that do not pay income taxes, i.e. the unemployed, the inactive or the retired, generally see a smaller increase in their real incomes than the employed or self-employed. Those who are not in work will not see very much of an increase in their real incomes as they do not benefit from the reduction in income taxes.

Second, a similar divide can be seen between the urban and rural groups. For both groups there is a positive change in real incomes but in all scenarios the urban population experiences greater increases than the rural group due to the smaller amount they spend on both transport and heating fuels.

As for the income groups, the middle-income quintiles seem to have the smallest increases in real incomes in most scenarios, due to the larger share of their income spent on both transport fuels and heating costs. The highest income group does not devote as large a proportion of its income to these expenditures whilst individuals within the lowest income group often do not own cars so do not encounter the associated increase in fuel costs.

For all groups, HS3 creates the largest increases in real incomes. In this scenario there is international cooperation between the EU and other external nations. The EU consequently reduces GHG emissions by 30 % via higher carbon prices, while other countries make comparable reductions. The revenue that is generated from this version of ETR is recycled via greater reductions in income taxes, leading to the greater increases in real incomes seen in the results. This scenario is particularly attractive because of the increased 'double dividend', whereby employment is stimulated whilst the environment is improved.

Prior to conducting the modelling exercise it might be thought that the lowest income group would gain the least from any ETR. If this were the case it would be apparent in the disaggregated real income growth figures for each income group. However, the results show that this is not the case. In fact the middle income groups, particularly the third quintile, see the smallest increase in their real incomes. These results are broadly consistent with those discussed in the literature review in this report.

Then again, there are several countries in which the lowest income quintile actually experiences no real income growth or even a slight fall, suggesting that the trade-off between decreased income taxes and increased fuel costs is negative. Furthermore, it can be seen that in these particular countries there is a big difference between the gains experienced by the richest and the poorest quintiles, suggesting that ETR could in fact create a less equal distribution of income. This is highly undesirable for policymakers as the vulnerable groups of the population such as the poor or unemployed are most likely to require social protection and should not automatically be disadvantaged by a change in policy.

3.4.2 Policy implications

The results show that ETR can increase real incomes for all groups and hence encourage employment, supporting the case for future ETR in the EU. In most countries, and at the aggregate EU level, the impacts were not found to be regressive across income groups.

However, the gains in income for different socio-economic groups are not necessarily equal, creating an unfavourable distribution of income, which could be made worse if more ambitious targets for reductions in emissions and material consumption were set. ETR could therefore be challenged by interest groups or individuals with income groups that lose out from the reforms. Alternative arrangements for support may therefore be required to make ETR politically feasible.

This report has not considered regulatory changes (for example promotion of electric vehicles) that would reduce energy and material consumption without increasing prices. It has also not considered the impacts of support for particular socio-economic groups. It is worth noting in this context, however, that the revenue recycling scheme used in the analysis is arguably a blunt instrument because it does not benefit groups such as pensioners and students. Different recycling mechanisms, such as increased direct transfers, could directly target these groups.

The conclusion from this exercise is that it is possible for ETR to stimulate employment, as real incomes could be increased via lower income taxes. There is therefore potential for a double dividend, in which employment is increased and the environment is improved. However, the policy must be carefully formulated at a detailed level in order to minimise the negative impacts of the reforms on particular socio-economic groups.

4 Distributional impacts of ETR in Germany: literature review and scenario study

To supplement the EU-wide modelling exercise presented in Chapter 3 of this report, the present chapter focuses on the distributional effects of a possible ETR in Germany, using both a literature review and a scenario study. More comprehensive data are available for Germany than for the EU as a whole, enabling more detailed modelling of the distributional impacts.

Using the established structural macroeconometric model PANTA RHEI and a socio-economic extension of the underlying Inforge system called DEMOS, the analysis assesses the repercussions of an ETR for the German economy as a whole, and, in particular, for the consumption patterns of 25 types of households in the year 2020. For each household type in DEMOS, the modelling involves spending on 41 consumption expenditure categories (see Tables A.1–A.4). These categories include expenditures on electricity, transport, gas and other fuels, which are immediately affected by the price changes set in motion by the reform and calculated with PANTA RHEI.

The results indicate that the proposed ETR would put a disproportionately high burden on lower-income households, including the unemployed and retirees. In other words, these households would spend a higher share of their disposable income on the affected expenditure items than the average household. Conversely, the middle class, consisting of employee households, would not be affected differently than the average household. The ETR would put the relatively lowest burden on the self-employed, being the highest-income group under consideration. Hence, the projected outcome is regressive, although the magnitude of the effects is remarkably modest. The study also shows that the ETR would generate additional employment and income that could in principle be used to mitigate adverse distributional effects.

The structure of the chapter is as follows. Section 4.1 presents a brief discussion of related studies for Germany, followed by a short analysis of historical data in Section 4.2. Section 4.3 provides a description of the modelling tools, PANTA RHEI and DEMOS. Section 4.4 sets out the modelling assumptions. Sections 4.5 and 4.6 present the results and Section 4.7 presents conclusions.

4.1 Literature review focusing on Germany

During the 1990s several European countries started to implement taxes on energy use and CO_2 emissions. This caused controversial public debates and led to a significant increase in research interest towards potential impacts of ETR on matters such as growth, employment, competitiveness and equity. Although the latter topic has not been accorded the highest priority, several publications have analysed income and consumption patterns of private households in Germany and the likely effects of introducing an ETR.

Barker and Köhler (1998) presented the first comprehensive long-term projection of distributional impacts of an ETR in 11 EU Member States until 2010, using their econometric E3ME model. Under a set of assumptions they estimate the change in expenditure of various low-to-middle-income consumer groups on 'environmentally sensitive goods and services' induced by taxes imposed on these products. Furthermore, they consider the use of revenues from the reform to reduce social security contributions.

Looking at cross-sectional data for 1988, the authors first find that as household expenditure rises, the proportion spent on domestic fuels diminishes, i.e. the poor spend a higher share of their income on fuel than higher-income groups. The opposite situation is found with respect to expenditures on transport, whose share increases with higher income.

The study's ETR simulation results indicate that in 2010 all socio-economic groups would gain in terms of disposable income in constant 1988 prices, while the tax burden becomes moderately more regressive. The authors use a regressivity measure developed in

Smith (1992), which is the ratio of tax payments as a percentage of total household expenditure of the poorest quartile over the same share of the richest quartile.

Germany experiences the most regressive impacts among the 11 countries evaluated in the study. This regressivity emerges due to an increased tax burden for domestic energy, mainly affecting the lowest income brackets and welfare and pension recipients. However, if the reform only included road fuels, the outcome would be progressive. Although compensating reductions of social security contributions mean that the ETR has positive net effects on household incomes, the authors conclude that additional policy measures must be implemented to correct the regressive effects, which markets cannot provide. As solutions, they suggest tax reductions for employers hiring lower-paid labour, using tax revenues to improve the energy efficiency of fuel use for poorer groups and raising their incomes directly via social security payments.

The crucial importance of the way in which revenues are recycled is also discussed in Johnstone and Serret (2006) and Serret and Johnstone (2006).

Germany initiated an ETR in 1999, gradually introducing measures until 2003. This process spawned a new wave of research, although little addressing distributional impacts. Exceptions include Bach et al. (2001 and 2002) and Grub (2000).

Bach et al. (2001 and 2002) combined a micro-simulation model (the 'Potsdamer' model) with a structural econometric model (PANTA RHEI) estimating short-term future impacts until 2003. The Potsdamer model was used to analyse the effects of an ETR at household level (micro level), based on detailed information on socio-economic conditions of private households in Germany such as direct and indirect taxes, social security contributions and transfers. The model differentiates between fossil fuel taxes on gasoline and diesel, fuel oil, natural gas and liquefied gas and includes data on gasoline and diesel consumption behaviour of private households.

At the time of the analysis, no time series data were available, so the data used were random samples from 1993, which were adjusted to 1998 (the base year) to reflect changes in the tax assessment base. In the reference scenario, the fiscal law from 1998 was assumed to be valid until 2003. The ETR was implemented in a second scenario.

The effects of the ETR, obtained by comparing the baseline scenario with the ETR scenario, were analysed for five different household sizes and eight different household types for 18 different income groups. The impacts on distribution were moderate, confirming the findings of earlier studies. Moreover, the studies confirmed that the total net burden of the ETR was generally regressive, although it was progressive at the highest income brackets due to lower impacts of reduced social security contributions for these groups.

With respect to household size, the study showed that the net tax burden in 2003 with the ETR would be higher for all households except single-occupiers in the middle-income range. Regarding socio-economic status, only households of middle-income employees without children would benefit from the ETR. The net burden also increases with expanding family size.

Bach et al. (2001 and 2002) also take into account the German income tax reform for the years 1999, 2000, 2003, which together with the ETR could be perceived as one big reform package. In general, the combined results show a mitigation or even overcompensation of the regressivity induced by the ETR.

Bork (2006) applied the same micro-simulation model as Bach et al. after the actual ETR, using official statistical data until 2003 in place of the forecast time-series data from PANTA RHEI. The results were very similar to the earlier studies, the only notable exception being that single-occupier households with middle incomes were now also negatively affected by the ETR, due to higher pension contributions than the forecast ones. In addition, the study confirms that the tax burden associated with energy was regressive, while showing that the burden associated with motor fuels had an inverted U-shaped pattern in income, i.e. first increasing then decreasing.

Leipprand et al. (2007) describe ETRs in five selected European countries, offering some new results concerning distributional impacts of taxes and charges on different household groups. These impacts are measured by estimating a group-specific proportion of taxes and charges to average group-specific income. There is no modelling involved, so the study is more of a crude assessment of current burdens created by environment-focused policies for different socio-economic groups.The study shows that the differences in relative net payments between income groups are small. Only the richest income group (of the six analysed) spends a smaller income share. When variation across status groups is considered (the authors distinguish between manual and non-manual workers, the unemployed, the retired and the inactive — information on the self-employed is not included in the Income and Expenditure Survey, which served as the data source), the inactive (e.g. students) bore the largest burden, followed by manual workers and the unemployed. Non-manual workers and the retired are relatively least affected by the taxes and charges.

Focusing on energy products consumed by households, the study shows that expenditure (and taxes) on personal transport fuels constitutes the largest category. Personal transport fuels account for the largest share of total expenditure of middle-income groups or, looking from another perspective, the expenditure of manual workers and the unemployed, followed by the non-manual workers. Conversely, the retired and inactive do not spend that much on mobility.

Bach (2009) confirms that the distributional effects of the German ETR in 2003 were moderate. According to that study, energy tax revenues accounted for 0.75 % of disposable income. The ETR burden relative to equivalence-weighted household income was highest for low-income households and regressively distributed. However, the inclusion of adjustments in pension payments mitigated impacts, so that only the poorest households and families with children were negatively affected.

Other sources quantifying distributional effects of the ETR include Symons et al. (2000) and Blum (2008). For an overview of the literature see Table A.5 in the Annex. And a broad international discussion is found in OECD (2006).

The most important insights resulting from the previous research are as follows:

- the German ETR of 1999–2003 was regressive in nature, i.e. the net burden as a proportion of income is highest for lowest-income households and decreases in relative terms as income increases;
- the absolute net financial impact is small;
- the ETR's regressivity is clear concerning energy expenditures and less clear relating to personal transport fuel consumption;
- households not benefiting from reduced social security payments (the unemployed and the retirees) bear the highest burden.

4.2 Historical distribution patterns

In order to assess distributional impacts of ETR it is useful to first examine historical data on the income of various groups and household types, and on their consumption patterns.

Table 4.1 shows the distribution of disposable income across household types in 2004, which was the most recent comprehensive official income data with a breakdown into sub-categories of the non-employed available at the time of preparing this report.

The data indicate the degree of after-tax income inequality among households in various socio-economic groups and with varying household sizes. Household groups are defined by the main source of income accruing to the main income recipient of a household. There are five categories of households in each group, i.e. households with one

Table 4.1 Average disposable incomes for different household types in EUR (2004)

	1 phh	2 phh	3 phh	4 phh	5 phh
Self-employed	80 200	113 400	108 100	120 900	135 500
Employees	23 100	41 200	46 000	52 100	54 000
Public officials	29 700	54 700	59 900	65 100	70 400
Salaried employees	24 700	44 900	50 700	58 400	61 500
Wage earners	17 800	31 200	37 500	41 800	44 800
Not employed	15 500	27 600	34 600	40 900	40 200
Unemployed	9 700	20 700	26 300	34 100	30 400
Retirees (excl. public officials)	15 900	26 800	38 800	46 800	52 800
Retired public officials	28 400	45 500	61 000	n.a.	n.a.
Welfare recipients	8 700	13 900	17 200	21 200	28 400
All households	21 000	37 700	48 900	59 000	63 000

Source: Federal Statistical Office of Germany, 2008.

person (1 phh), two persons (2 phh), three persons (3 phh), four persons (4 phh) and five or more persons (5+ phh).

Households whose main income recipients are self-employed receive at least twice the average income accruing to all households (shown in the bottom row of the table) and up to almost four times the average in the case of one-person households.

Employee households' incomes are similar to the average, especially those of salaried employees constituting the majority of such households (almost 52 % of employee households and 25 % of all households). Among employee households, wage earners receive the least, while public officials have the highest remunerations in this group.

For all sizes of household, non-employed persons have less disposable income than the average, with the exception of retired public officials. There is a significant difference between retired persons with higher incomes and the lower-income groups of the unemployed and welfare recipients.

In order to simplify the analysis and make the results more comparable in the international context, results presented below will refer to only five groups and five household sizes. In DEMOS, nine socio-economic groups are used in the modelling, which is important when addressing specific aspects of the German system. The data can later be aggregated according to needs, as in the present case.

The five groups are households of the self-employed, employees, retirees, the unemployed (including welfare recipients) and a residual category called 'others', which consists of non-employed persons receiving most of their incomes from dividend payments, rental activities or relatives. This group's heterogeneity makes it hard to interpret but it is required for the completeness of the analysis.

Table 4.2 shows the relative weight of these household types according to their number. It reveals that the biggest groups — employees and retirees — constitute 80 % of all households. Interestingly, retiree households make up the largest share of the two smallest household sizes.

The consumption structure of the involved status groups is presented in Tables 4.3 and 4.4. The data are from the year 2002, which is the last historical time-point of consumption modelling for which DEMOS uses original structural data from the German Federal Statistical Office.

Table 4.2 Percentage shares of household types in total number of households (2004)

	1 Phh	2Phh	3 Phh	4 Phh	5+ Phh	Total
Self-employed	1.6	2.1	1.4	1.4	0.6	7.0
Employees	13.1	12.2	8.7	7.0	2.6	44.4
Retirees	16.4	16.5	2.0	0.5	0.2	35.6
Unemployed	3.8	2.6	1.5	1.0	0.6	9.5
Others	2.1	0.9	0.4	0.2	0.0	3.5
Total	37.0	34.2	14.0	10.7	4.0	100.0

Table 4.3 Household group spending on selected consumption categories — expressed as a percentage of total consumption expenditure by each household group (2002)

		Household group					
No	Category	Self-employed	Employees	Retirees	Unemployed	Others	Average
11	Electricity, gas and other fuels	3.7	3.4	4.4	4.5	3.4	3.8
22	Operation of personal transport equipment	6.5	7.5	4.6	5.5	5.7	6.4
23	Transport services	2.2	2.1	2.2	2.4	3.1	2.2
7–11	Housing, water, electricity, gas and other fuels	22.4	21.5	26.5	28.4	25.0	23.5
21–23	Transport services	14.3	15.6	10.9	11.0	14.1	13.8
	Total	100.0	100.0	100.0	100.0	100.0	100.0

Note: The table shows the proportion of each household group's total consumption expenditure that is spent on each expenditure category. For example, self-employed households devote 3.7 % of their total consumption spending to electricity, gas and other fuels, 6.5 % to operation of personal transport equipment and 2.2 % to transport services.

A complete version of this table, including all 41 consumption expenditure categories is presented in the annex as Table A.1.

Table 4.3 shows that low-income households, i.e. retirees and the unemployed, spend a disproportionately high share of their consumption expenditure on electricity, gas and other fuels, whereas the share of the self-employed is close to the average and the share of the employees is below average. Therefore, it could intuitively be expected that higher prices for energy would have a regressive impact on household expenditure, i.e. they would be disproportionately disadvantageous for the poorest households in terms of imposing additional spending on energy relative to income, barring additional adjustments.

The implications of transport expenditure data are less clear, especially the category 'operation of personal transport equipment', which includes spare parts, accessories, fuels, lubricants, maintenance, repair and other services related to personal transport equipment. The category accounts for an above-average share of the total spending of employed households. Contrastingly, poorer households, which use automobiles less, spend a lower share of total expenditure on this category.

Table 4.4 Household group spending on selected consumption categories — expressed as a percentage of consumption spending by all households on that category (2002)

		Household group					
No	Category	Self-employed	Employees	Retirees	Unemployed	Others	Total
11	Electricity, gas and other fuels	15.3	43.5	33.1	6.1	2.0	100.0
22	Operation of personal transport equipment	26.0	57.1	20.5	1.5	2.0	100.0
23	Transport services	15.5	47.8	27.9	5.7	3.1	100.0
7–11	Housing, water, electricity, gas and other fuels	15.0	44.5	31.9	6.3	2.3	100.0
21–23	Transport services	16.3	55.0	22.3	4.1	2.2	100.0
	Average	15.7	48.6	28.3	5.2	2.2	100.0

Note: The table shows the amount that each household group spends on a consumption category as a proportion of total spending on that consumption category. For example, self-employed households account for 15.3 % of total spending on electricity, gas and other fuels, employed households 43.5 %, retiree households 33.1 %, unemployed households 6.1% and other households 2 %. Together the households account for 100 % of spending on electricity, gas and other fuels.

A complete version of this table, including all 41 consumption expenditure categories is presented in the annex as Table A.2.

Table 4.4 presents a different perspective on household consumption, showing the shares of each household group in total spending on each product category. For energy consumption, it is evident that although employee households consume 43.5 % of the total, this share lies below their share of all consumption categories (presented in the bottom row of the table), which amounts to 48.6 %. Conversely, poorer households (retirees and unemployed) spend a higher proportion on energy than their average across all categories. Self-employed households' share of spending on energy does not greatly differ from their average spending behaviour (which is also true for the other two relevant consumption categories — 'operation of personal transport equipment' and 'transport services').

Among the remaining household groups, the spending patterns on the two transport categories vary, probably reflecting car ownership and usage across these groups. Consequently, the share of spending on the 'operation of personal transport equipment' is disproportionately high for employee households relative to their average share and also very large in absolute terms (57.1 %), while the groups partly excluded from car use, again retirees and unemployed households, devote less than their average consumption share to this category. Contrastingly, employees use relatively less public transportation, which is reflected in their less-than-average spending share, while the unemployed spend significantly more on transport services.

4.3 PANTA RHEI and DEMOS models

The ETR modelling in this chapter relies on two models, PANTA RHEI and DEMOS, which are described below.

PANTA RHEI

The macroeconometric model PANTA RHEI is used to quantify the effects of ETRs using various scenarios. PANTA RHEI is an ecologically extended version (Bach et al., 2002; Lutz et al., 2005; Meyer et al., 2007a; Lutz et al., 2007; Lehr et al., 2008) of the 59-sector econometric simulation and forecasting model Inforge (Meyer et al., 2007b). The Inforge model depicts the German economy in great detail and PANTA RHEI links it, via detailed housing and transport modules, to the German energy balance and related CO_2 emissions. Demographic development, international variables such as

Figure 4.1 Simplified model structure of PANTA RHEI

energy prices and growth of world trade, and more technical parameters such as heating values are some of the few exogenous variables.

PANTA RHEI is an econometric input-output model, offering the ability to model bounded rationality decisions using a broad empirical database. PANTA RHEI is constructed in a completely integrated manner, using a bottom-up approach. The latter principle means that each sector of the economy is modelled in great detail and macroeconomic aggregates are calculated by explicit aggregation.

The model describes the inter-industry flows between the 59 sectors and their contributions to macroeconomic variables such as personal consumption, government spending, investment, changes in stocks and exports. It also includes prices, wages, output, imports, employment, labour compensation, profits and taxes, and describes income redistribution in complete detail. One further strength of the model is its high level of interdependence, for instance between prices and wages or between prices and volumes demanded and supplied.

Final demand is calculated based on the disposable income of private households, the interest rates and profits, the world trade variables and the relative prices for all components and product groups of final demand. For all intermediary inputs, domestic inputs are distinguished from imports. Final production and imports are derived from final and intermediary demand. Employment is determined from the production volume and the real wage rate in each sector, which in turn depends on labour productivity and prices.

The effects of a given policy measure are calculated by comparing 'with measure' simulations against a reference scenario without any measures. Comparing the changes in the macroeconomic indicators in each scenario conveys the net economic effects on the labour market, on GDP and so on.

DEMOS

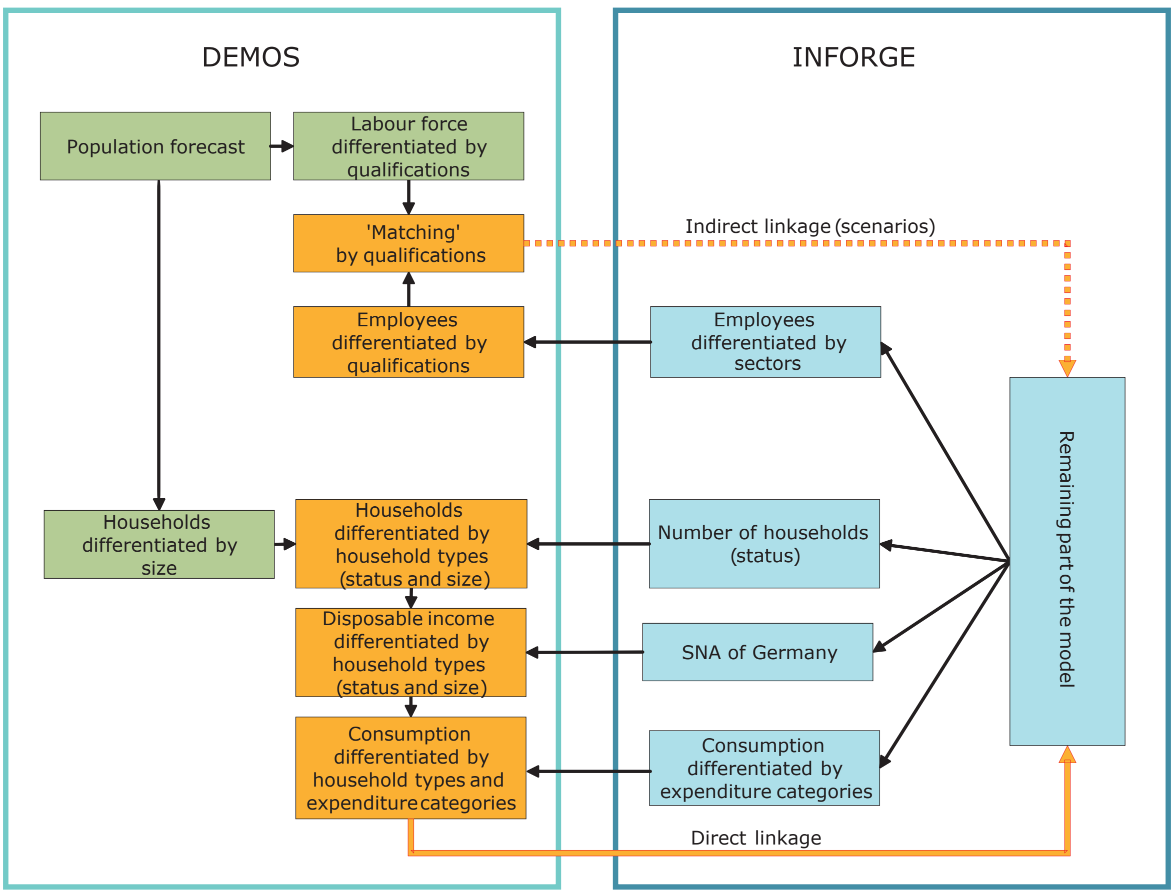
The DEMOS module was developed to provide a socio-economic extension to the existing Inforge/PANTA RHEI models. Its first version was completed in 2004 and focused on labour market disaggregation by formal qualification. In the new version, DEMOS II (see Drosdowski and Wolter, 2008), labour market modelling has been extended via more comprehensive time-series data, enabling deeper analysis. However, the main upgrade was the inclusion of detailed household data consistent with the German System of National Accounts (SNA).

DEMOS contains differentiated household structures and information about their income generation and distribution, and consumption patterns (Figure 4.2). The time-series data used (historically from 1991 to 2004) encompass 45 household categories combining nine socio-economic groups and five different household sizes.

Both demographic and economic developments drive the structural composition of household income. At each point in time, every type of household receives specific market income flows (wages, salaries and profits), is subject to taxation and social security payments, and receives government transfers. The redistributed primary incomes yield disposable incomes that are subsequently devoted to consumption and saving.

Similarly, each type of household displays a distinct consumption structure using its disposable income on 41 expenditure categories (Tables A.1 and A.2). Spending on individual consumption categories varies over time according to group-specific income developments and price changes, generating structural shifts in consumption patterns across groups. The paths of different consumption items rely on almost 2 000 empirically estimated relationships. Such a complex approach is required in order to capture adequately the varying influences on consumption for heterogeneous groups that do not respond to income or price changes in a uniform way.

Figure 4.2 DEMOS module



Integrated with Inforge, DEMOS is well equipped to analyse policy changes by means of simulations. For instance, exogenous politically initiated price changes affect all markets and households simultaneously, leading to changing income and consumption patterns within and between household types over time.

The present study analyses distributional impacts using constant consumption structures for the year 2020 along with a constant distribution of disposable incomes between household types generated by DEMOS. In particular, it assumes a constant distribution of each consumption expenditure category between the household types, analysing the effects of price changes and behavioural adjustments caused by the ETR and given by PANTA RHEI.

4.4 Scenario assumptions

This study builds on the petre project undertaken for the Anglo-German foundation (Ekins and Speck, 2011). Six scenarios outlined in Lutz and Meyer (2009) were implemented in the petre project using two international model systems, GINFORS and E3ME. The baseline is adjusted to the EU's 2008 energy forecast (DG TREN 2008) and at the global level to the International Energy Agency's World Energy Outlook (2008). Other scenarios build on the EU's GHG emission reduction targets until 2020.

To determine the distributional impacts of an ETR, the present study uses two alternative carbon prices, derived from the GINFORS model system, and analysed in PANTA RHEI. The first was the carbon price in the baseline (BH). The second was derived from the scenario HS1, which assumes that the EU ETS and ETR are used to reach the EU's unilateral 20 % GHG emissions reduction target in the context of higher global energy prices. The carbon price according to HS1 rises to EUR 68/t CO_2 in 2020. As in the petre scenarios, tax revenues are recycled through reductions in income tax rates and social security contributions.

4.5 Aggregate impacts of the ETR based on the PANTA RHEI model

Compared to the baseline, the overall macroeconomic impact (on the key variables set out in Table 4.5) of introducing a carbon tax in the non-ETS sector increasing to 68 Euro/t CO2 in 2020 is very small.

Table 4.5 shows that the price increase of carbon-intensive products leads to an overall increase of the consumer price index (CPI). Among prices for consumption expenditure categories, the price for 'electricity, gas and other fuels' increases by 21 %, while the price for 'operation of personal transport equipment' increases by 15 %.

As ETR revenues are recycled via reductions in social security contributions, labour costs decrease, which is the main driver for the additional employment of 152 000 in 2020 against the baseline. The employment increase is concentrated in trade and service sectors (see Table 4.6).

Table 4.5 Macroeconomic impacts of scenario HS1 in Germany — deviations from baseline BH in 2020 (PANTA RHEI)

	Absolute values	Deviation in %
GDP (Bill. EUR in 2000 prices)	– 0.1	0.0
Household consumption	3.3	0.2
Government consumption	2.0	0.4
Equipment	0.6	0.2
Construction	0.2	0.1
Exports	– 0.4	0.0
Imports	3.3	0.2
CPI (2000 = 100)	2.25	1.84
Disposable income (nominal)	23.2	1.2
Employment in 1 000	152	0.4

Table 4.6 Sectoral employment effects of ETR — deviation from the baseline in 2010, 2015 and 2020 (PANTA RHEI)

	Absolute values			Deviation in %		
	2010	2015	2020	2010	2015	2020
Employment						
Agriculture, hunting, forestry and fishing	1.1	2.9	4.5	0.2	0.6	0.8
Mining and quarrying	1.2	3.7	6.2	1.4	5.6	12.5
Manufacturing	3.2	1.1	– 5.9	0.0	0.0	– 0.1
Electricity, gas and water supply	0.8	1.7	2.2	0.3	0.7	1.1
Construction	2.6	4.3	5.5	0.1	0.2	0.3
Wholesale and retail trade, repair	12.5	29.3	39.3	0.2	0.6	0.7
Hotels and restaurants	7.2	17.1	24.3	0.5	1.0	1.4
Transport, storage and communications	5.2	12.3	17.9	0.3	0.7	1.0
Financial intermediation	0.4	0.9	1.1	0.0	0.1	0.1
Real estate, renting and business activities	5.9	13.4	18.4	0.1	0.3	0.3
Public administration and defence, social sec.	13.6	26.3	33.4	0.5	1.1	1.4
Education	3.0	5.4	5.3	0.1	0.3	0.3
Health and social work	0.2	1.0	– 0.7	0.0	0.0	0.0
Other community, social and personal services	2.7	6.2	7.7	0.2	0.4	0.4
Private households with employed persons	– 1.2	– 3.5	– 6.7	– 0.2	– 0.5	– 0.9
Total	**58.2**	**122**	**152**	**0.2**	**0.3**	**0.4**

Note: The figures show the deviation from the baseline scenario expressed in absolute values (1 000s) and as a percentage.

4.6 Projected distributional impacts based on the DEMOS model

4.6.1 *Distributional impact of the ETR as a whole*

In order to study distributional impacts, some structural data for 2020 were taken from DEMOS and combined with information from both relevant PANTA RHEI scenarios. The distributional impact of the ETR as a whole is measured by considering the total impact on household consumption of energy and transport relative to disposable income.

Table 4.7 Changes in the proportion of household groups' total disposable income spent on selected consumption categories as a result of the ETR (expressed in percentage points)

		Household group					
No	Category	Self-employed	Employees	Retirees	Unemployed	Others	Average
1	Food	– 0.07	– 0.11	– 0.14	– 0.19	– 0.10	– 0.11
11	Electricity, gas and other fuels	0.48	0.61	0.94	0.98	0.56	0.67
22	Operation of personal transport equipment	0.30	0.45	0.33	0.41	0.33	0.38
23	Transport services	0.22	0.27	0.33	0.35	0.33	0.28
7–11	Housing, water, electricity, gas and other fuels	0.42	0.54	0.84	0.89	0.49	0.59
21–23	Transport services	0.45	0.63	0.59	0.69	0.59	0.57
	Total	**0.39**	**0.57**	**0.70**	**0.80**	**0.55**	**0.56**

Note: A complete version of this table, including all 41 consumption expenditure categories is presented in the annex as Table A.3.

Table 4.7 shows changes in the proportion of each household group's total disposable income that is devoted to each consumption category as a result of the ETR (expressed in percentage points). As shown in the bottom row, all household groups experience an increase in consumption expenditure as a proportion of disposal income, implying a reduction in saving. On average household spending on consumption increases by 0.56 percentage points. Unemployed households experience a much greater shift than average (0.8 percentage points) and self-employed households experience a smaller shift (0.39 percentage points).

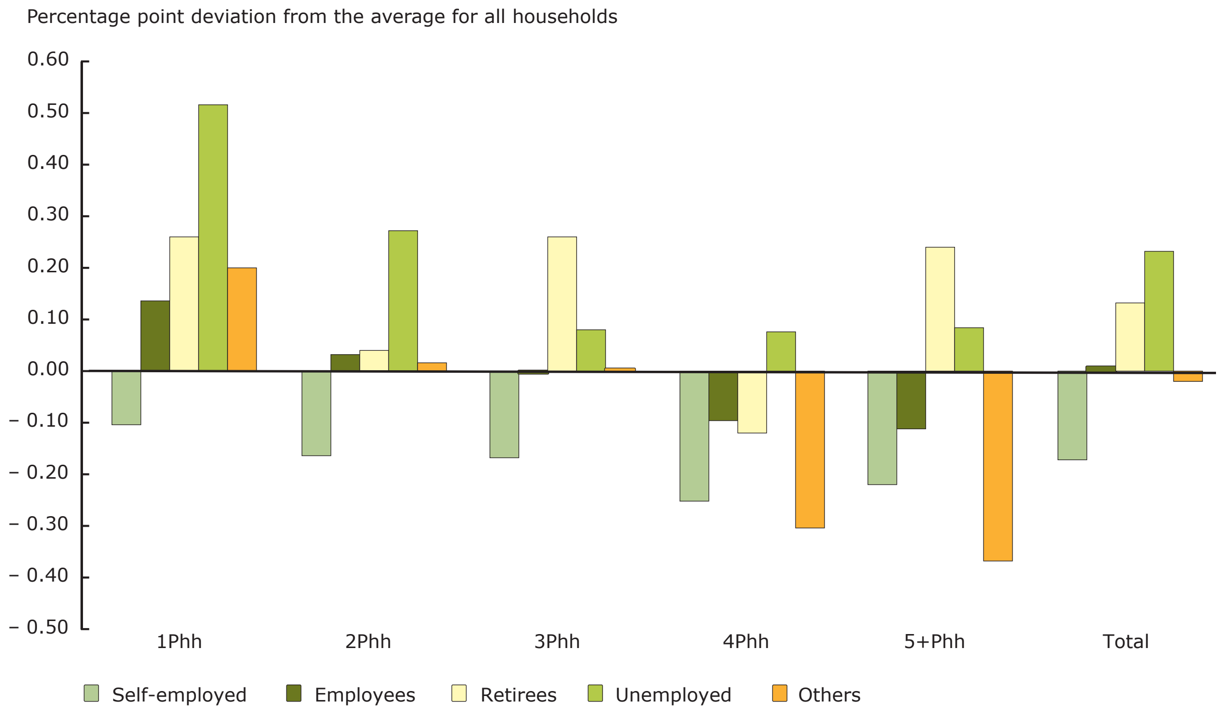
Figure 4.3 disaggregates the results in the bottom row of Table 4.7 by family size. It presents the results as percentage-point deviations from the average (0.56 percentage points). Positive values denote an above-average increase in expenditure on energy and transport relative to household income and vice versa.

The same normalisation is applied in the analysis of individual expenditure items discussed below.

Figure 4.3 clearly indicates that the ETR contributes to expenditure shifts between household types and groups. Poorer households boost their consumption spending — expressed in percentage points of disposable income relative to the average — disproportionately in comparison to the other household types.

Overall, the group that bears the highest burden from the ETR, particularly among smaller households, is unemployed households. All unemployed household sizes face above-average increases in consumption spending as a proportion of disposable income. Since, on average, the unemployed household types have consumption shares exceeding one — meaning that they are indebted — the indebtedness of these households increases slightly.

Figure 4.3 Total ETR burden on household types and sizes relative to the average for all households



Note: Y-axis units are the deviation from the average (0.56 percentage points) for all households. The 'total' column on the right comprises the aggregated figures for each household type, as per the bottom row of Table 4.7.

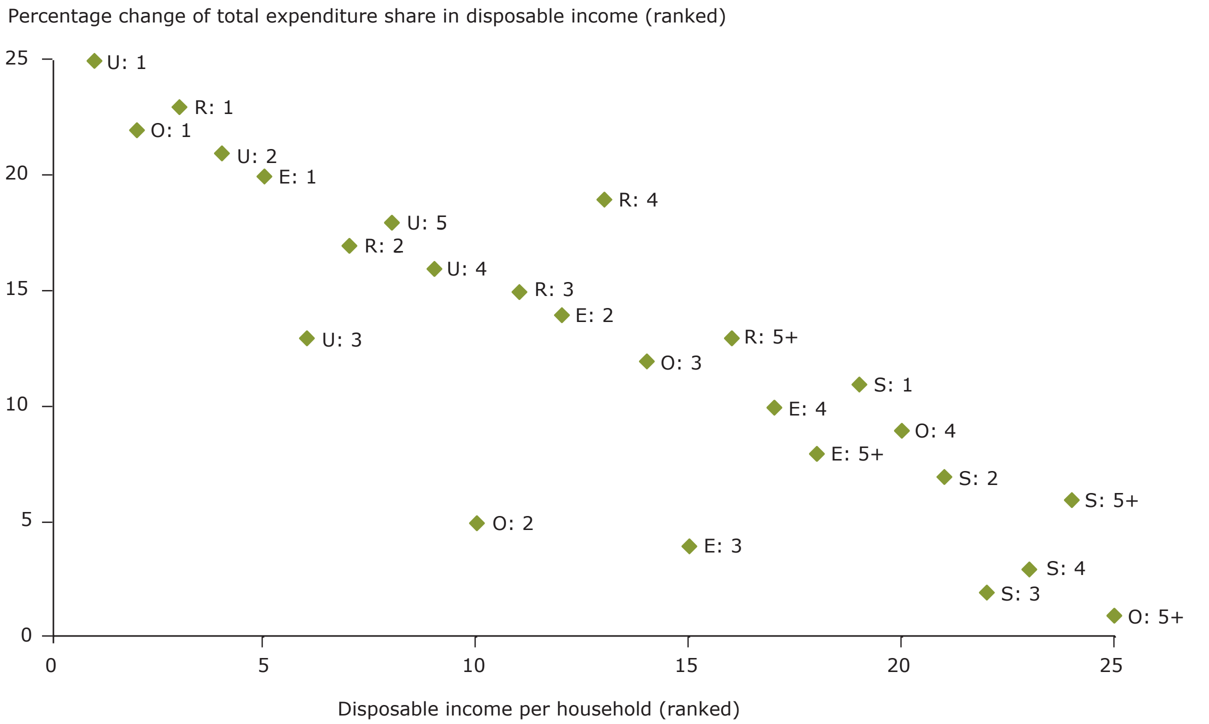
Retiree households, the second poorest group, also face the second-highest overall increases in consumption spending. These are highest for three-person households and households with five or more persons. However, retirees living in four-person households face below-average increases in consumption spending as a proportion of disposable income.

Whereas unemployed households of all sizes acquire additional burdens compared to the average, all sizes of self-employed households enjoy disproportionately low burdens in terms of the increase in consumption spending relative to disposable income. Among employee households the overall change in expenditure shares relative to the average declines as household size increase. It is positive for single households and two-person households and negative for larger ones. Overall, the share for employee households matches that of the average household.

Finally, the group of 'others' displays large increases in relative spending among poorer single households and large reductions in relative spending among the two biggest household types. As Table 4.1 shows, the smaller households in this group are among the poorest overall, whereas the biggest ones receive the highest incomes. This difference is probably explained by the heterogeneity of income sources of this particular group.

In order to clarify the findings, the household types were ranked according to their average disposable income and plotted against the ranked change in consumption expenditure's share in disposable income. As Figure 4.4 displays, the relationship is clearly negative: the poorest households located at the left side of the income scale face the highest relative increase in consumption expenditure as a share of disposable incomes and the relative burden declines as incomes increase. This is a regressive outcome.

Figure 4.4 Burden of ETR in terms of household consumption expenditure as a proportion of disposable income



Note: The letters and numbers next to the points on the graph indicate the household type and size. Letters denote groups (S: self-employed; E: employed; R: retirees; U: unemployed; O: others), digits denote size (e.g. 5+ stands for households with five or more persons). The numbers at the axis indicate rank (from low (0) to high (25)).

The results suggest that the poorest households may be forced to carry the burden of the ETR by increasing their consumption expenditure shares and thus their indebtedness.

4.6.2 Distributional impacts of the change in spending on energy resulting from the ETR

It is also instructive to analyse how the ETR changes the share of relevant expenditure categories in total household expenditure, as presented in Table 4.7.

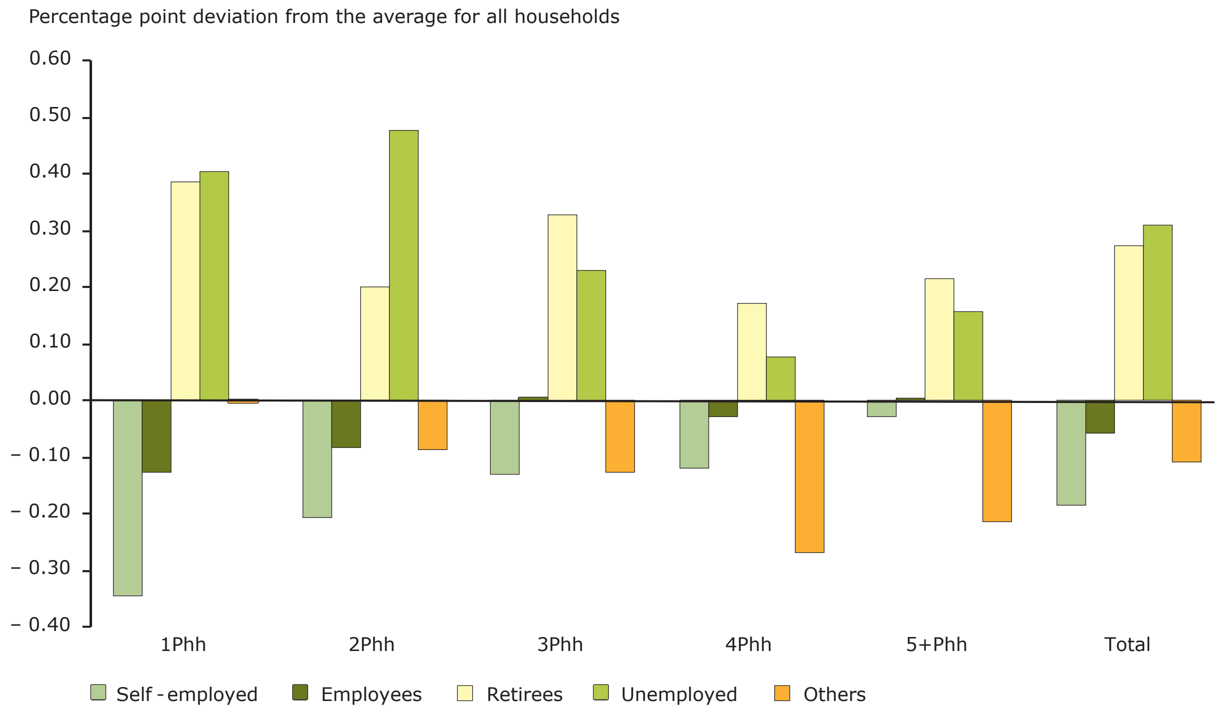
As shown in Table 4.7 (consumption category 11), all household groups face an increase in spending on energy as a proportion of disposable income, with unemployed and retiree households increasing significantly more than average and self-employed households by much less than average.

Figure 4.5 disaggregates these general results according to household size. It shows the percentage-point changes to the shares of energy (electricity, gas and other fuels) expenditure in disposable income across household types, relative to the average change for all households.

The figure shows that the expenditure shares of energy for the poorer households increase by more than average, while the shares for higher-income households increase by less than average. This captures the regressivity of the ETR measures with respect to energy prices and confirms the empirical evidence found in previous studies (see Section 4.1).

The rising expenditure share of energy partly explains the nature of changes of total consumption as a share of disposable incomes for these groups shown in Figure 4.5.

Figure 4.5 Additional household expenditure on electricity, gas and other fuels as a share of disposable income



Note: The y-axis units are the deviation from the average for all households (i.e. a 0.67 pp increase). The 'total' column on the right comprises the aggregated figures for each household type and therefore corresponds to the figures in category 11 'electricity, gas and other fuels' in Table 4.7.

Table 4.3 revealed that, of all the household groups, poorer households devote the largest share of their consumption spending to electricity, gas and other fuels. Table 4.8 shows that the ETR augments that disparity. The share of consumption spending used on energy increases for all household groups but the increase is well above the average of 0.78 percentage points in the case of retirees (0.94 percentage points) and unemployed households (0.90 percentage points). The additional shares for the other groups are below average.

Table 4.8 Changes in the percentage of total consumption expenditure by household groups on selected consumption categories as a result of the ETR (expressed in percentage points)

		Household group					
No	Category	Self-employed	Employees	Retirees	Unemployed	Others	Average
1	Food	− 0.16	− 0.20	− 0.22	− 0.28	− 0.21	− 0.20
11	Electricity, gas and other fuels	0.73	0.71	0.94	0.90	0.72	0.78
22	Operation of personal transport equipment	0.43	0.49	0.31	0.35	0.40	0.42
23	Transport services	0.32	0.31	0.33	0.31	0.41	0.32
7–11	Housing, water, electricity, gas and other fuels	0.51	0.49	0.66	0.64	0.46	0.55
21–23	Transport services	0.61	0.65	0.53	0.58	0.69	0.61
	Total	0.00	0.00	0.00	0.00	0.00	0.00

Note: The data presented here represent the percentage point alterations in the proportion of each household group's total consumption expenditure spent on each expenditure category. As such, they constitute the alterations to the data presented in Table 4.3 as a result of the ETR. For example, whereas self-employed households previously devoted 3.7 % of their consumption spending to electricity, gas and other fuels (see Table 4.3), after the ETR they would use 3.7 + 0.73 = 4.43 % of their consumption spending on this category.

A complete version of this table, including all 41 consumption expenditure categories is available in the annex as Table A.4.

4.6.3 Distributional impacts of the change in spending on operation of personal transport equipment resulting from the ETR

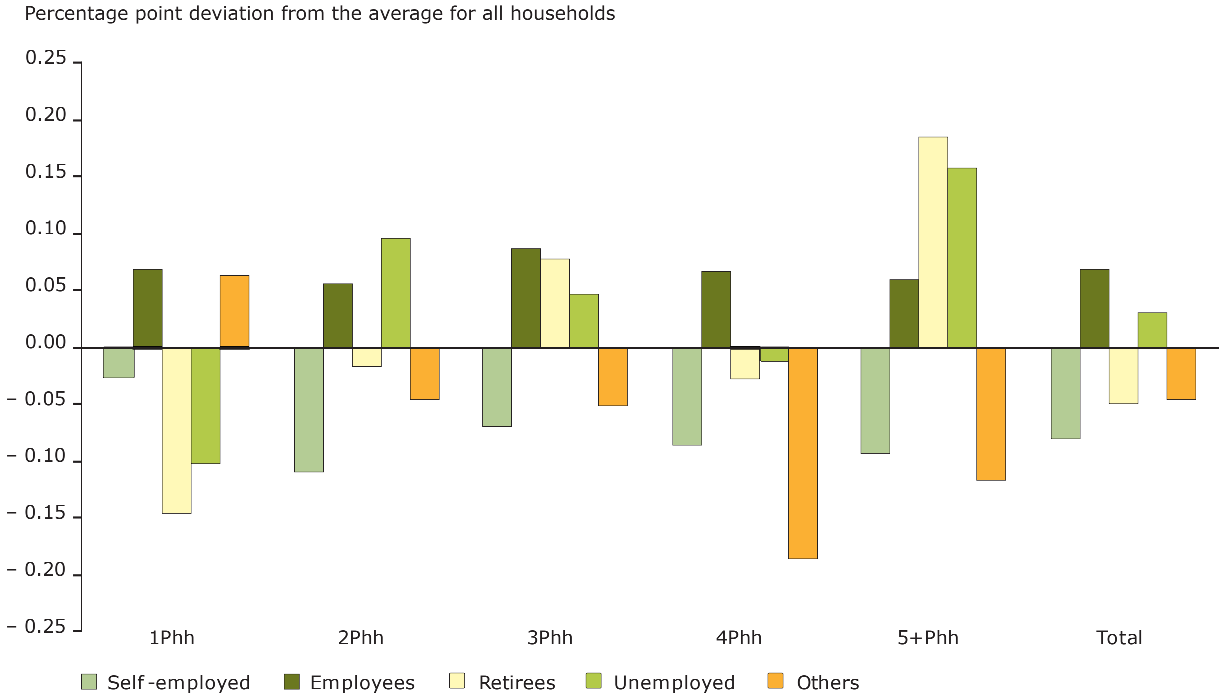
The situation is different with respect to 'operation of personal transport equipment'. As Table 4.8 shows, employee households face above-average increases in this category's share of total consumption spending. The change for the self-employed is close to the average, while the change for both poorest groups is below average.

The distribution of share gains corresponds to the initial distribution of consumption spending on this category (Table 4.3). This is skewed towards employee households, which operate and own the largest share of cars in society. Unsurprisingly, higher prices for this expenditure item affect their consumption disproportionately.

At the opposite extreme, household groups owning and using automobiles relatively less experience a below-average increase in spending on 'operation of personal transport equipment' as a proportion of total consumption expenditure.

Category 22 in Table 4.7 shows that spending on 'operation of personal transport equipment' as a proportion of disposable income increases for all household types as a result of the ETR. Figure 4.6 disaggregates these data by household size, presenting the percentage point deviation from the average increase.

Figure 4.6 Additional household expenditure on operation of personal transport equipment as a share in disposable income



Note: The y-axis units are the deviation from the average for all households (i.e. a 0.38 percentage point increase). The 'total' column on the right comprises the aggregated figures for each household type and therefore corresponds to the figures in category 22 'operation of personal transport equipment' in Table 4.7.

As Figure 4.6 shows, employee households face an above-average increase in the proportion of total disposable income spent on operation of personal transport equipment. However, unemployed households also face an above-average increase, with a particularly heavy burden falling on households with five or more persons. In addition, unemployed households face the largest burden increase for two-person households.

Although retiree households face the largest increase for households of five or more and a significant increase for three-person households, they face the increases furthest below average among single households. Since the old-age population constitutes the largest group among the single households (over 40 % in 2004), the share for all retiree households declines. As in the previous case of energy, self-employed households face below-average increases across all household sizes.

The patterns apparent in Figure 4.6 do not present a clear conclusion on whether the ETR has a regressive or progress impact on this expenditure category, since both low-income and high-income groups are positively or negatively affected relative to the average. The literature reviewed in Chapter 2 and Table A.5 of the Annex also indicate mixed results for this category.

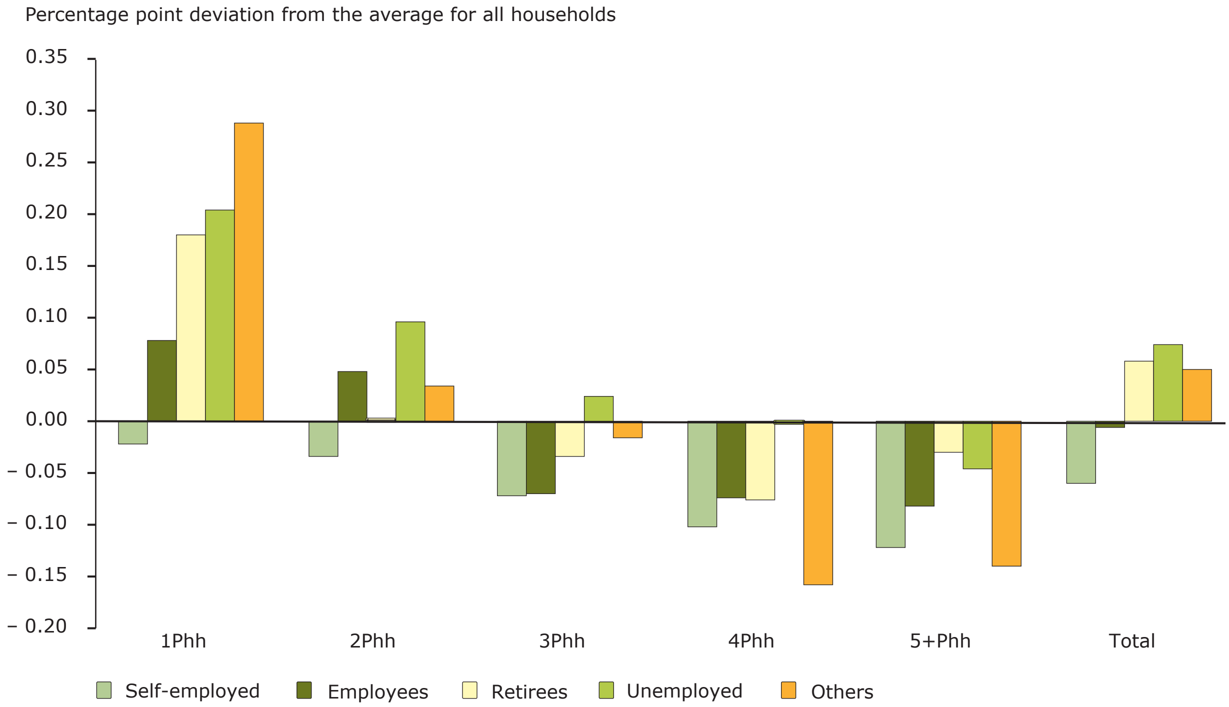
4.6.4 Distributional impacts of the change in spending on transport service resulting from the ETR

The last consumption category directly affected by the ETR is 'transport services'. As Table 4.8 indicates, all household groups increase the proportion of consumption spending on this category but there is very little deviation from the average, except for households in the 'others' group.

Analysis of changes of in expenditure on transport services as a share of disposable income (shown in category 23 of Table 4.7) reveals a greater degree of distributional impacts. These data are disaggregated by household size in Figure 4.7.

The additional expenditure on transport services as a proportion of disposable income declines with rising household size. Relative to the average, the increase

Figure 4.7 Additional household expenditure on transport services as a share in disposable income



Note: The y-axis units are the deviation from the average for all households (i.e. a 0.28 percentage point increase). The 'total' column on the right comprises the aggregated figures for each household type and therefore corresponds to the figures in category 23 'transport services' in Table 4.7.

is particularly large for poorer single households. Across household groups, the unemployed, retired and the other non-employees display disproportionately high burdens, while employee and self-employed households face below-average increases. These patterns clearly indicate that the ETR has regressive impacts for this expenditure category.

4.6.5 Distributional impacts of the change in spending on food resulting from the ETR

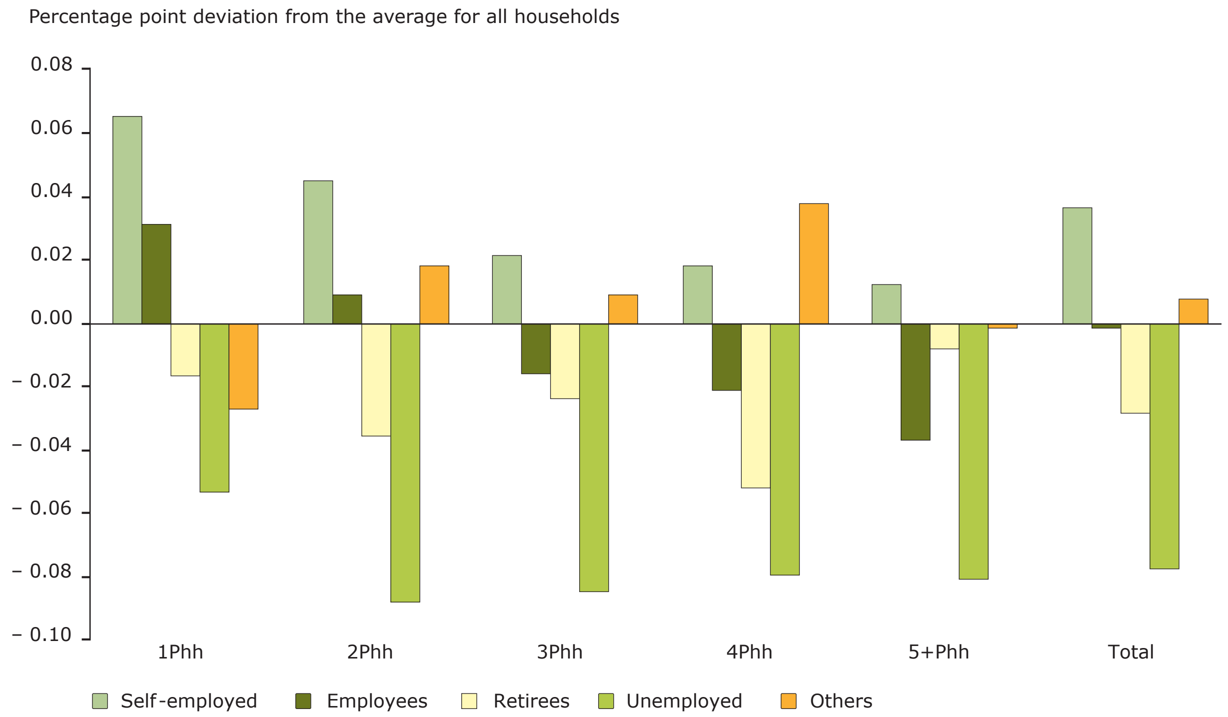
In order to provide some additional evidence that the ETR implies regressive outcomes, the distributional impacts on spending on food as a proportion of disposable income are also considered. Food is chosen because, as Table 4.8 shows, it is the only relevant spending category besides vehicle purchases where the reduction in spending as a proportion of total disposable income is significant (ranging from a drop of 0.07 pp for self-employed households to a 0.19 pp reduction for unemployed households — see Table A.3).

Figure 4.8 disaggregates the data in category 1 of Table 4.8 according to household size. It shows clearly that unemployed households reduce their spending on food as a proportion of disposable income by far more than average. Retiree households of all sizes also reduce their relative spending by more than average, albeit to a smaller degree.

Contrastingly, self-employed households face a smaller-than-average reduction in their spending on this category as a proportion of disposable income. Among employee households, one- and two-person households face smaller-than-average reductions in spending, while larger households face larger-than-average reductions.

Overall, retiree and unemployed households experience above-average falls in spending on food as a proportion of disposable income, the self-employed face below-average falls and employee household spending declines by an amount close to the average.

Figure 4.8 Reduction in household expenditure on food as a share in disposable income



Note: The y-axis units are the deviation from the average for all households (i.e. a 0.11 percentage point decrease). The 'total' column on the right comprises the aggregated figures for each household type and therefore corresponds to the data in category 1 'food' in Table 4.7.

In sum, the distributional impact of the ETR is regressive because for poorer households the additional consumption expenditure is almost exclusively used on environment-related goods that these households cannot easily avoid. As seen in the food example, they are also forced to consume less basic items, which normally account for a larger share of disposable incomes.

4.6.6 Changes in nominal expenditures on key consumption categories resulting from the ETR

Finally, the effects of the ETR across household groups can be also quantified. Table 4.9 shows the additional expenditures in EUR on the environment-related consumption items, along with the percentage point changes in shares of disposable income in parentheses (taken from Table A.3 and rounded to one decimal place).

Table 4.9 Changes of nominal expenditures across households due to ETR in EUR

	Self-employed	Employees	Retirees	Unemployed	Others
Electricity, gas and other fuels	830	350	294	222	172
	(0.5)	(0.6)	(0.9)	(1.0)	(0.6)
Operation of personal transport equipment	556	276	112	101	110
	(0.3)	(0.4)	(0.3)	(0.4)	(0.3)
Transport services	378	157	106	81	102
	(0.2)	(0.3)	(0.3)	(0.4)	(0.3)

Note: The consumption changes in percentage points of disposable income are included in parentheses.

It is clear that additional burden is rather moderate for all household groups, even the unemployed and retirees in the case of energy expenditures. The maximum additional spending on energy as a proportion of disposable income in just 1 %. Compensating the poorest households for this impact would be relatively easy and inexpensive.

In view of this additional insight, it can be stated that the study confirms the main findings of the literature in this area, demonstrating that the proposed ETR is mildly regressive, especially with respect to energy consumption.

4.7 Conclusions

The foregoing analysis of a possible ETR in Germany confirms the most important results of related studies in that country. Specifically, it concludes that such reforms tend to have slightly regressive effects on the household expenditure. Accordingly, lower-income groups not benefiting from reduced social security contributions such as unemployed and retiree households incur the highest burdens in terms of additional expenditure for environment-related goods and services whose prices change due to the ETR. This is especially true of energy expenditure.

Employee households are not particularly affected in their overall consumption in disposable income in comparison to the average household, even though their nominal expenditure on motor fuels is disproportionately increased. The self-employed, which are the highest-income household group of all those analysed, face a below-average increase in spending on energy and transport as a proportion of disposable income.

The analysis also shows that the ETR is associated with higher employment, lower unemployment and higher disposable income at the macro level. Because the use of revenues from environmental taxes is crucial for the distributional effects of an ETR, part of this additional income could be redistributed in order to correct its regressive effects.

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Annex

Table A.1 Household group spending on each consumption category — expressed as a percentage of total consumption expenditure by each household group (2002)

No	Category	Self-employed	Employees	Retirees	Unemployed	Others	Average
1	Food	8.8	10.0	10.6	12.8	9.3	10.1
2	Non-alcoholic beverages	1.4	1.5	1.3	1.8	1.3	1.5
3	Alcoholic beverages	1.4	1.7	1.8	1.9	1.5	1.7
4	Tobacco	1.5	2.3	1.2	3.8	1.8	1.9
5	Clothing	5.1	5.1	4.5	3.9	4.3	4.8
6	Footwear	0.9	0.9	0.8	0.9	0.8	0.9
7	Actual rentals for housing	5.0	6.6	7.8	14.6	9.5	7.2
8	Imputed rentals for housing	10.7	8.7	10.7	6.1	8.7	9.5
9	Maintenance and repair of the dwelling	0.7	0.6	0.9	0.5	0.9	0.7
10	Water supply and misc. services rel. to dwelling	2.3	2.2	2.7	2.7	2.5	2.4
11	Electricity, gas and other fuels	3.7	3.4	4.4	4.5	3.4	3.8
12	Furniture and furnishings, carpets etc.	3.2	3.1	2.7	2.8	3.0	3.0
13	Household textiles	0.6	0.6	0.7	0.5	0.5	0.6
14	Household appliances	0.9	0.9	1.2	0.9	0.9	1.0
15	Glassware, tableware and household utensils	0.6	0.6	0.6	0.5	0.6	0.6
16	Tools and equipment for house and garden	0.5	0.7	0.7	0.6	0.5	0.6
17	Goods and services for routine household maintenance	1.6	1.4	1.7	1.5	1.2	1.5
18	Medical products, appliances and equipment	1.2	1.2	2.6	0.9	1.4	1.6
19	Outpatient services	1.9	1.5	2.0	0.7	1.7	1.7
20	Hospital services	0.8	0.8	2.0	0.3	0.8	1.1
21	Purchase of vehicles	5.7	6.0	4.1	3.1	5.3	5.3
22	Operation of personal transport equipment	6.5	7.5	4.6	5.5	5.7	6.4
23	Transport services	2.2	2.1	2.2	2.4	3.1	2.2
24	Postal services	0.2	0.2	0.2	0.3	0.3	0.2
25	Telephone and telefax equipment	0.2	0.2	0.2	0.2	0.2	0.2
26	Telephone and telefax services	2.3	2.3	2.5	3.2	3.0	2.4
27	Audio-visual, photographic and information processing	1.7	2.1	1.5	1.9	2.0	1.9
28	Other major durables for recreation and culture	0.3	0.3	0.1	0.2	0.2	0.2
29	Other recreational items and equipment, gardens and pets	1.9	1.9	1.9	1.9	1.7	1.9
30	Recreational and cultural services	3.2	3.4	3.4	3.1	3.2	3.3
31	Newspapers, books and stationary	1.8	1.9	2.2	2.1	2.2	2.0

Table A.1 Household group spending on each consumption category — expressed as a percentage of total consumption expenditure by each household group (2002) (cont.)

No	Category	Self-employed	Employees	Retirees	Unemployed	Others	Average
32	Package holidays	0.3	0.3	0.4	0.2	0.2	0.3
33	Education	1.0	0.8	0.3	0.6	1.1	0.7
34	Catering services	5.0	4.9	4.4	3.5	5.0	4.7
35	Accomodation services	0.8	0.8	0.8	0.5	0.6	0.8
36	Personal care	1.9	2.0	2.1	2.0	1.9	2.0
37	Personal effects n.e.c.	0.9	0.9	1.0	0.6	0.7	0.9
38	Social protection	1.1	1.2	0.9	1.1	0.8	1.1
39	Insurance	5.6	3.1	2.2	2.0	2.4	3.1
40	Financial services n.e.c.	3.3	2.7	2.8	2.5	3.8	2.8
41	Other services n.e.c.	1.6	1.5	1.5	1.1	1.9	1.5
1–4	Food, beverages and tobacco	13.1	15.5	14.9	20.3	13.9	15.1
5–6	Clothing and footwear	6.0	6.0	5.3	4.8	5.1	5.7
7–11	Housing, water electricity, gas and other fuels	22.4	21.5	26.5	28.4	25.0	23.5
12–17	Furnishings, household equipment and routine household maintenance	7.4	7.2	7.5	6.7	6.8	7.3
18–20	Health	3.9	3.6	6.6	1.9	3.9	4.4
21–23	Transport services	14.3	15.6	10.9	11.0	14.1	13.8
24–26	Communication	2.6	2.7	2.9	3.7	3.4	2.8
27–32	Recreation and culture	9.2	10.0	9.7	9.3	9.6	9.7
33	Education	1.0	0.8	0.3	0.6	1.1	0.7
34–35	Restaurants and hotels	5.8	5.7	5.2	4.0	5.6	5.5
36–38	Personal services	3.8	4.2	3.9	3.7	3.5	4.0
39–40	Finance	8.9	5.8	4.9	4.5	6.2	6.0
41	Other services n.e.c.	1.6	1.5	1.5	1.1	1.9	1.5
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Note: The table shows the proportion of each household group's total consumption expenditure that is spent on each expenditure category. For example, self-employed households devote 8.8 % of their total spending to food, 1.4 % to non-alcoholic beverages and 1.4 % to alcoholic beverages. Correspondingly, the sum of all categories (1–41) accounts for 100 % of each household group's consumption spending.

n.e.c.: not elsewhere classified.

Table A.2 Household group spending on each consumption category — expressed as a percentage of consumption spending by all households on that category (2002)

No	Category	Self-employed	Employees	Retirees	Un-employed	Others	Total
1	Food	13.7	48.0	29.7	6.6	2.0	100.0
2	Non-alcoholic beverages	15.1	51.0	25.5	6.4	2.0	100.0
3	Alcoholic beverages	12.8	49.2	30.2	6.0	1.9	100.0
4	Tobacco	12.3	57.5	18.0	10.2	2.0	100.0
5	Clothing	16.6	50.9	26.3	4.2	2.0	100.0
6	Footwear	16.0	51.6	25.0	5.3	2.0	100.0
7	Actual rentals for housing	10.9	44.8	30.8	10.6	2.9	100.0
8	Imputed rentals for housing	17.8	44.7	32.1	3.4	2.0	100.0
9	Maintenance and repair of the dwelling	15.9	43.3	33.9	4.0	2.8	100.0
10	Water supply and misc. services rel. to dwelling	15.4	44.8	31.6	5.9	2.3	100.0
11	Electricity, gas and other fuels	15.3	43.5	33.1	6.1	2.0	100.0
12	Furniture and furnishings, carpets etc.	16.8	50.4	25.8	4.8	2.2	100.0
13	Household textiles	14.9	47.1	31.6	4.4	2.0	100.0
14	Household appliances	14.1	44.7	34.2	5.0	2.0	100.0
15	Glassware, tableware and household utensils	15.9	50.8	26.9	4.3	2.2	100.0
16	Tools and equipment for house and garden	13.4	51.6	28.7	4.6	1.8	100.0
17	Goods and services for routine household maintenance	17.2	43.7	32.2	5.1	1.8	100.0
18	Medical products, appliances and equipment	12.2	37.4	45.7	2.8	1.9	100.0
19	Outpatient services	17.5	43.7	34.4	2.3	2.2	100.0
20	Hospital services	11.3	36.1	49.6	1.4	1.6	100.0
21	Purchase of vehicles	17.0	55.6	22.1	3.1	2.2	100.0
22	Operation of personal transport equipment	16.0	57.1	20.5	4.5	2.0	100.0
23	Transport services	15.5	47.8	27.9	5.7	3.1	100.0
24	Postal services	14.8	46.6	29.2	6.9	2.7	100.0
25	Telephone and telefax equipment	14.8	46.5	29.1	6.9	2.7	100.0
26	Telephone and telefax services	14.7	46.6	29.1	6.8	2.7	100.0
27	Audio-visual, photographic and information processing	13.9	55.4	23.2	5.2	2.3	100.0
28	Other major durables for recreation and culture	19.6	57.0	16.7	4.5	2.3	100.0
29	Other recreational items and equipment, gardens and pets	15.7	49.2	28.0	5.0	2.0	100.0
30	Recreational and cultural services	15.3	49.1	28.7	4.8	2.1	100.0
31	Newspapers, books and stationary	14.1	46.1	31.9	5.4	2.5	100.0
32	Package holidays	14.2	44.4	36.9	3.1	1.4	100.0
33	Education	23.3	56.9	11.9	4.5	3.4	100.0
34	Catering services	16.7	50.9	26.2	3.9	2.3	100.0
35	Accomodation services	16.6	48.5	30.0	3.2	1.6	100.0
36	Personal care	14.4	49.1	29.2	5.2	2.1	100.0
37	Personal effects n.e.c.	15.5	48.4	30.6	3.7	1.8	100.0
38	Social protection	15.5	54.7	22.9	5.2	1.7	100.0
39	Insurance	28.0	47.4	19.6	3.4	1.7	100.0
40	Financial services n.e.c.	18.3	46.6	27.7	4.5	2.9	100.0
41	Other services n.e.c.	16.6	48.0	28.7	3.9	2.8	100.0

Table A.2 Household group spending on each consumption category — expressed as a percentage of consumption spending by all households on that category (2002) (cont.)

No	Category	Self-employed	Employees	Retirees	Un-employed	Others	Total
1–4	Food, beverages and tobacco	13.6	49.6	27.8	7.0	2.0	100.0
5–6	Clothing and footwear	16.5	51.0	26.1	4.4	2.0	100.0
7–11	Housing, water electricity, gas and other fuels	15.0	44.5	31.9	6.3	2.3	100.0
12–17	Furnishings, household equipment and routine household maintenance	16.0	48.1	29.1	4.8	2.1	100.0
18–20	Health	14.0	39.5	42.4	2.3	1.9	100.0
21–23	Transport services	16.3	55.0	22.3	4.1	2.2	100.0
24–26	Communication	14.8	46.6	29.1	6.8	2.7	100.0
27–32	Recreation and culture	14.9	49.8	28.2	5.0	2.2	100.0
33	Education	23.3	56.9	11.9	4.5	3.4	100.0
34–35	Restaurants and hotels	16.7	50.6	26.7	3.8	2.2	100.0
36–38	Personal services	14.9	50.5	27.8	4.9	1.9	100.0
39–40	Finance	23.4	47.0	23.4	3.9	2.3	100.0
41	Other services n.e.c.	16.6	48.0	28.7	3.9	2.8	100.0
	Average	15.7	48.6	28.3	5.2	2.2	100.0

Note: The table shows the amount that each household group spends on a consumption category as a proportion of total spending on that consumption category. For example, self-employed households account for 13.7 % of total spending on food, employed households 48 %, retiree households 29.7 %, unemployed households 6.6 and other households 2 %. Together the households account for 100 % of spending on food.

n.e.c.: not elsewhere classified.

Table A.3 Changes in the proportion of household groups' total disposable income spent on each consumption category as a result of the ETR (expressed in percentage points)

No.	Category	Self-employed	Employees	Retirees	Un-employed	Others	Average
1	Food	– 0.07	– 0.11	– 0.14	– 0.19	– 0.10	– 0.11
2	Non-alcoholic beverages	– 0.02	– 0.02	– 0.02	– 0.03	– 0.02	– 0.02
3	Alcoholic beverages	– 0.01	– 0.02	– 0.02	– 0.03	– 0.01	– 0.02
4	Tobacco	0.00	0.01	0.01	0.02	0.01	0.01
5	Clothing	– 0.04	– 0.05	– 0.05	– 0.05	– 0.03	– 0.05
6	Footwear	0.00	0.00	0.00	– 0.01	0.00	0.00
7	Actual rentals for housing	0.00	– 0.01	– 0.01	– 0.02	– 0.01	– 0.01
8	Imputed rentals for housing	– 0.03	– 0.04	– 0.05	– 0.03	– 0.03	– 0.04
9	Maintenance and repair of the dwelling	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01
10	Water supply and misc. services rel. to dwelling	– 0.02	– 0.03	– 0.04	– 0.04	– 0.03	– 0.03
11	Electricity, gas and other fuels	0.48	0.61	0.94	0.98	0.56	0.67
12	Furniture and furnishings, carpets etc.	0.02	0.03	0.03	0.03	0.03	0.03
13	Household textiles	0.00	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01
14	Household appliances	– 0.01	– 0.01	– 0.01	– 0.02	– 0.01	– 0.01
15	Glassware, tableware and household utensils	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01
16	Tools and equipment for house and garden	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01
17	Goods and services for routine household maintenance	– 0.02	– 0.02	– 0.02	– 0.03	– 0.01	– 0.02
18	Medical products, appliances and equipment	– 0.01	– 0.02	– 0.04	– 0.01	– 0.01	– 0.02
19	Outpatient services	– 0.02	– 0.02	– 0.03	– 0.01	– 0.02	– 0.02
20	Hospital services	– 0.01	– 0.01	– 0.03	0.00	– 0.01	– 0.01
21	Purchase of vehicles	– 0.07	– 0.09	– 0.07	– 0.07	– 0.07	– 0.08
22	Operation of personal transport equipment	0.30	0.45	0.33	0.41	0.33	0.38
23	Transport services	0.22	0.27	0.33	0.35	0.33	0.28
24	Postal services	0.00	0.00	0.00	0.00	0.00	0.00
25	Telephone and telefax equipment	0.00	0.00	0.00	– 0.01	0.00	0.00
26	Telephone and telefax services	– 0.03	– 0.03	– 0.04	– 0.05	– 0.04	– 0.03
27	Audio-visual, photographic and information processing	0.00	0.00	0.00	0.00	0.00	0.00
28	Other major durables for recreation and culture	0.00	0.00	0.00	0.00	0.00	0.00
29	Other recreational items and equipment, gardens and pets	– 0.02	– 0.03	– 0.03	– 0.04	– 0.02	– 0.03
30	Recreational and cultural services	– 0.03	– 0.05	– 0.05	– 0.05	– 0.03	– 0.05
31	Newspapers, books and stationary	– 0.02	– 0.03	– 0.04	– 0.04	– 0.03	– 0.03
32	Package holidays	0.00	0.00	0.00	0.00	0.00	0.00
33	Education	– 0.01	– 0.02	– 0.01	– 0.02	– 0.02	– 0.01
34	Catering services	0.01	0.01	0.01	0.01	0.01	0.01
35	Accomodation services	– 0.02	– 0.02	– 0.03	– 0.02	– 0.01	– 0.02
36	Personal care	– 0.02	– 0.03	– 0.03	– 0.04	– 0.02	– 0.03
37	Personal effects n.e.c.	– 0.01	– 0.01	– 0.02	– 0.01	– 0.01	– 0.01
38	Social protection	– 0.02	– 0.03	– 0.03	– 0.06	– 0.03	– 0.03
39	Insurance	– 0.04	– 0.03	– 0.02	– 0.02	– 0.02	– 0.03
40	Financial services n.e.c.	– 0.04	– 0.04	– 0.05	– 0.06	– 0.07	– 0.05
41	Other services n.e.c.	– 0.02	– 0.02	– 0.03	– 0.02	– 0.02	– 0.02

Table A.3 Changes in the proportion of household groups' total disposable income spent on each consumption category as a result of the ETR (expressed in percentage points) (cont.)

No.	Category	Self-employed	Employees	Retirees	Un-employed	Others	Average
1–4	Food, beverages and tobacco	– 0.09	– 0.14	– 0.18	– 0.22	– 0.12	– 0.14
5–6	Clothing and footwear	– 0.05	– 0.06	– 0.06	– 0.06	– 0.03	– 0.05
7–11	Housing, water electricity, gas and other fuels	0.42	0.54	0.84	0.89	0.49	0.59
12–17	Furnishings, household equipment and routine household maintenance	– 0.02	– 0.02	– 0.04	– 0.04	– 0.01	– 0.02
18–20	Health	– 0.04	– 0.05	– 0.09	– 0.03	– 0.04	– 0.06
21–23	Transport services	0.45	0.63	0.59	0.69	0.59	0.57
24–26	Communication	– 0.03	– 0.03	– 0.04	– 0.06	– 0.04	– 0.03
27–32	Recreation and culture	– 0.08	– 0.11	– 0.13	– 0.14	– 0.09	– 0.11
33	Education	– 0.01	– 0.02	– 0.01	– 0.02	– 0.02	– 0.01
34–35	Restaurants and hotels	– 0.01	– 0.01	– 0.02	– 0.01	– 0.01	– 0.01
36–38	Personal services	– 0.05	– 0.07	– 0.08	– 0.11	– 0.06	– 0.07
39–40	Finance	– 0.08	– 0.07	– 0.07	– 0.08	– 0.09	– 0.07
41	Other services n.e.c.	– 0.02	– 0.02	– 0.03	– 0.02	– 0.02	– 0.02
	Total	**0.39**	**0.57**	**0.70**	**0.80**	**0.55**	**0.56**

Note: The figures presented here represent the percentage point alterations in the proportion of each household group's total disposable income spent on each consumption category.

Figures shown in red indicate that the ETR caused a decline or no change in the nominal share in total consumption expenditure.

n.e.c.: not elsewhere classified.

Table A.4 Changes in the percentage of total consumption expenditure by household groups on each consumption category as a result of the ETR — expressed in percentage points

No.	Category	Self-employed	Employees	Retirees	Un-employed	Others	Average
1	Food	– 0.16	– 0.20	– 0.22	– 0.28	– 0.21	– 0.20
2	Non-alcoholic beverages	– 0.04	– 0.04	– 0.03	– 0.05	– 0.04	– 0.04
3	Alcoholic beverages	– 0.02	– 0.04	– 0.03	– 0.04	– 0.02	– 0.03
4	Tobacco	0.00	– 0.01	0.00	– 0.01	– 0.01	0.00
5	Clothing	– 0.09	– 0.09	– 0.08	– 0.07	– 0.05	– 0.08
6	Footwear	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01
7	Actual rentals for housing	– 0.04	– 0.05	– 0.07	– 0.11	– 0.08	– 0.06
8	Imputed rentals for housing	– 0.12	– 0.11	– 0.13	– 0.07	– 0.11	– 0.11
9	Maintenance and repair of the dwelling	– 0.01	– 0.01	– 0.02	– 0.01	– 0.02	– 0.01
10	Water supply and misc. services rel. to dwelling	– 0.05	– 0.05	– 0.06	– 0.06	– 0.05	– 0.05
11	Electricity, gas and other fuels	0.73	0.71	0.94	0.90	0.72	0.78
12	Furniture and furnishings, carpets etc.	0.02	0.02	0.01	0.01	0.02	0.02
13	Household textiles	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01
14	Household appliances	– 0.02	– 0.01	– 0.02	– 0.02	– 0.02	– 0.02
15	Glassware, tableware and household utensils	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01	– 0.01
16	Tools and equipment for house and garden	– 0.01	– 0.02	– 0.02	– 0.01	– 0.01	– 0.01
17	Goods and services for routine household maintenance	– 0.04	– 0.03	– 0.04	– 0.04	– 0.02	– 0.03
18	Medical products, appliances and equipment	– 0.03	– 0.03	– 0.06	– 0.02	– 0.03	– 0.04
19	Outpatient services	– 0.04	– 0.04	– 0.05	– 0.01	– 0.04	– 0.04
20	Hospital services	– 0.02	– 0.02	– 0.04	– 0.01	– 0.02	– 0.03
21	Purchase of vehicles	– 0.14	– 0.15	– 0.10	– 0.09	– 0.12	– 0.13
22	Operation of personal transport equipment	0.43	0.49	0.31	0.35	0.40	0.42
23	Transport services	0.32	0.31	0.33	0.31	0.41	0.32
24	Postal services	0.00	0.00	0.00	0.00	0.00	0.00
25	Telephone and telefax equipment	0.00	0.00	0.00	– 0.02	0.00	0.00
26	Telephone and telefax services	– 0.06	– 0.05	– 0.06	– 0.07	– 0.08	– 0.05
27	Audio-visual, photographic and information processing	– 0.01	– 0.02	– 0.01	– 0.02	– 0.01	– 0.01
28	Other major durables for recreation and culture	– 0.01	– 0.01	0.00	– 0.01	0.00	0.00
29	Other recreational items and equipment, gardens and pets	– 0.05	– 0.05	– 0.05	– 0.05	– 0.04	– 0.05
30	Recreational and cultural services	– 0.07	– 0.08	– 0.08	– 0.07	– 0.06	– 0.08
31	Newspapers, books and stationary	– 0.04	– 0.04	– 0.05	– 0.05	– 0.05	– 0.05
32	Package holidays	0.00	0.00	0.00	0.00	0.00	0.00
33	Education	– 0.03	– 0.03	– 0.01	– 0.02	– 0.03	– 0.02
34	Catering services	– 0.02	– 0.02	– 0.02	– 0.02	– 0.02	– 0.02
35	Accomodation services	– 0.03	– 0.03	– 0.03	– 0.03	– 0.03	– 0.03
36	Personal care	– 0.04	– 0.05	– 0.05	– 0.05	– 0.04	– 0.05
37	Personal effects n.e.c.	– 0.02	– 0.02	– 0.02	– 0.01	– 0.02	– 0.02
38	Social protection	– 0.04	– 0.05	– 0.04	– 0.08	– 0.06	– 0.04
39	Insurance	– 0.10	– 0.06	– 0.04	– 0.03	– 0.04	– 0.06
40	Financial services n.e.c.	– 0.08	– 0.07	– 0.07	– 0.08	– 0.13	– 0.07
41	Other services n.e.c.	– 0.03	– 0.04	– 0.04	– 0.03	– 0.05	– 0.04

Table A.4 Changes in the percentage of total consumption expenditure by household groups on each consumption category as a result of the ETR — expressed in percentage points (cont.)

No.	Category	Self-employed	Employees	Retirees	Un-employed	Others	Average
1–4	Food, beverages and tobacco	– 0.23	– 0.28	– 0.29	– 0.37	– 0.27	– 0.27
5–6	Clothing and footwear	– 0.10	– 0.10	– 0.09	– 0.08	– 0.06	– 0.09
7–11	Housing, water electricity, gas and other fuels	0.51	0.49	0.66	0.64	0.46	0.55
12–17	Furnishings, household equipment and routine household maintenance	– 0.07	– 0.07	– 0.08	– 0.08	– 0.06	– 0.07
18–20	Health	– 0.09	– 0.09	– 0.15	– 0.04	– 0.09	– 0.10
21–23	Transport services	0.61	0.65	0.53	0.58	0.69	0.61
24–26	Communication	– 0.06	– 0.05	– 0.06	– 0.09	– 0.08	– 0.06
27–32	Recreation and culture	– 0.18	– 0.20	– 0.20	– 0.20	– 0.18	– 0.20
33	Education	– 0.03	– 0.03	– 0.01	– 0.02	– 0.03	– 0.02
34–35	Restaurants and hotels	– 0.05	– 0.05	– 0.06	– 0.05	– 0.05	– 0.05
36–38	Personal services	– 0.10	– 0.11	– 0.11	– 0.15	– 0.11	– 0.11
39–40	Finance	– 0.18	– 0.13	– 0.11	– 0.11	– 0.18	– 0.14
41	Other services n.e.c.	– 0.03	– 0.04	– 0.04	– 0.03	– 0.05	– 0.04
	Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Note: The figures presented here represent the percentage point alterations in the proportion of each household group's total consumption expenditure spent on each expenditure category. As such, they constitute the alterations to the figures presented in Table A.1 as a result of the ETR. For example, whereas self-employed households previously devoted 3.7 % of their consumption spending to electricity, gas and other fuels, after the ETR they would use 3.7 + 0.73 = 4.43 % of their consumption spending on this category.

Figures shown in red indicate that the ETR caused a decline or no change in the nominal share in total consumption expenditure.

n.e.c.: not elsewhere classified.

Table A.5 Overview of literature focusing on distributional impacts of ETR in Germany

Source	Model type	Subject of analysis	Data source	Main results
Bach et al. (2001, 2002)	Microsimulation model (Potsdamer model); structural econometric macromodel (PANTA RHEI)	Net impact of ETR on household groups (1998-2002); income classes, household sizes, social groups, age, gender	Income and Consumption Survey (1993), Tax authoritys income taxation data (1993), Socio-economic Panel (selected waves), SNA data from Federal Statistical Office of Germany	Total net burden decreasing with disposable income, only slightly increasing for highest incomes; total net burden lowered only for middle-income single households and employees without children; burden increasing with family size; higher burdens for households without lowered social sec. contributions; relative burden much higher in lower income range, while *relative relief increasing with income*
Bach (2009)	No model	Net impact of ETR on households in 2003; income deciles, household types	Income and Consumption Survey (2003)	ETR is mildly regressive: relative tax-burden of lower income households higher than of high-income households; reduced social security contributions reduce the regressivity: net burden only for the poorest and families with children
Barker and Köhler (1998)	Structural econometric macromodel (E3ME)	Net burden of ETR across different groups; linear increased excise duties on energy products (1999-2010); lower expenditure groups by proportion of average expenditure (0.4 to 1.6 times); tax neutrality: additional revenue reduces social security contributions	German survey data converted into Eurostat Family Budget categories	1988: percentage of total expenditure on electricity, gas and other fuels declining, percentage share of vehicle purchases + purchased transport increasing ETR: changes in disp. inc. increasing with income in proportion to average; every group benefits, vulnerable groups (social transfers, pensions) similar to bottom two expenditure groups benefit less than the average; regressivity ratio highest in Germany, regressivity due to increased taxes on domestic energy, if only road fuels taxed - progressivity due to carbon contents as tax base; overall: weak regressivity
Blum (2008)	No model	Share of electricity costs in household net income; 20 income groups	Socio-economic Panel	Percentage share of ETR costs declining with income; poorest households disproportionately affected; distribution regressive
Bork (2006)	Microsimulation model (Potsdamer model)	Net impact of ETR on household groups (1998-2002); income classes, household sizes, social groups, age, gender	Income and Consumption Survey (1993), Tax authoritys income taxation data (1993), Socio-economic Panel (selected waves), SNA data from Federal Statistical Office of Germany	Mostly the same results as in Bach et al. (2001,2002); overall: tax burden decreasing with income for energy, inverted U-shaped pattern in income for motor fuel; single households in middle income range also with burden in contrast to Bach et al. (2001)

Table A.5 Overview of literature focusing on distributional impacts of ETR in Germany (cont.)

Source	Model type	Subject of analysis	Data source	Main results
Grub (2000)	Static I-O model (ÖkoMik) for tax revenue generation; no model for distributional impacts	Net financial burdens of the ETR; shares of net household income and total consumption; 10 income/consumption groups	Income and Consumption Survey (1993)	Lower-income, transfer-receiving households disproportionately affected; reduction of social security payments increases regressivity gas taxes slightly regressiv, electricity and oil stronger automobile fuel taxes slightly regressive too, mitigate the total regressivity
Leipprand et al. (2007)	No model	Estimation of taxes and charges and comparison with disposable incomes for each group; excise taxes for energy and fees/charges on water and waste six income groups	Directorate General Taxation and Customs Union (2007) Income and Consumption Survey	Outcome regressive; env.-related taxes and charges as % of disposable income relatively lower for highest income group; no self-employed, but inactive highest (students and others), manual workers and unemployed medium and non-manual workers and retired lower; singles with lowest burdens, rising with household size; middle-income groups spend largest income shares for motor fuel, manual workers and unemployed with highest burden, retired with lowest; singles pay less taxes on energy, burden decreasing with income, retired and inactive with highest tax shares
Symons et al. (2000)	IO framework	Impacts of pollution and energy taxes on households; annual total expenditure as a ratio of total expenditure; six income groups; only effects of taxes, not revenue	Federal Statistical Office of Germany (IOT 1994, Umweltgesamt-rechnung 1995); German expenditure survey (StBA 1994)	Tax burden for CO_2 and energy (share of expenditure) decreasing in income taxes regressive, energy slightly more

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