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POLICY PAPER

The Distributional Impact of a Carbon Tax in Ireland

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Abstract: We study the effects of carbon taxation and revenue recycling across the income distribution in Ireland. Price changes of fuels and all other final goods and services are taken into account. If applied only to the emissions not covered by the EU Emissions Trading Scheme, a carbon tax of €20/tCO_2 would cost the poorest households around €3.5/week and the richest ones €5/week. The tax is regressive, therefore. However, if the revenue is used to increase social benefits and tax credits, households across the income distribution can be made better off without exhausting the total carbon tax revenue.

I INTRODUCTION

In 2006, Irish greenhouse gas (GHG) emissions were 25 per cent higher than in 1990, that is, 11.5 percentage points above the Kyoto target (2008-2012).[1] According to the government's "National Climate Change Strategy 2007-2012", one fifth of this gap will be bridged through the purchase of carbon credits, for which €290 million were allocated. Though there is reason to think that the government underestimated the cost of compliance with Kyoto,[2] the main focus should be on the target set by the EU for 2020. Indeed, in twelve years Ireland has to cut its emissions outside the EU Emissions Trading

[1] In 2007, emissions were about 10 percentage points above the Kyoto target (EPA, 2009a).
[2] The latest projections of Irish emissions (EPA, 2009b) show that the distance from the Kyoto target is close enough to what is indicated in the "National Climate Change Strategy 2007-2012". However, the government's figures crucially do not take account of the current economic crisis.

Scheme (ETS) by at least 20 per cent compared to 2005, with tightly restricted use of flexible mechanisms. Almost 60 per cent of the emissions from the non-ETS sector are CO_2 and the rest are methane (CH_4), mostly from cattle. Therefore, any strategy aimed at reducing these emissions should target both CO_2 and CH_4.

A carbon tax – or, more appropriately, a "CO_2 tax"[3] – is a charge to be paid on every fossil fuel, proportional to the quantity of CO_2 produced when it is burnt. Hence, the higher the carbon content (per unit of energy) of a fuel, the bigger its price increase. In principle, a carbon tax is the most cost-effective instrument for reducing CO_2 emissions (Piser, 1999; Nordhaus, 2005; Yohe *et al.*, 2007). In the specific instance, a carbon tax should: 1) apply only to the non-ETS sector; and 2) be as close as possible to the ETS price of carbon (Tol, 2007). This is the case because: (1) if the tax was also levied on emissions covered by the ETS, the cut on these would be offset by an equivalent increase somewhere else in the EU ("carbon leakage"); and (2) the smaller the gap between the tax and the ETS price of carbon, the smaller the welfare loss from distortions in output markets (Bohringer *et al.*, 2006). Such a tax would effectively extend the ETS cap to all CO_2 emissions and, most importantly, thereby strengthen the carbon price signal. The tax assumed in the analysis that follows has both characteristics. Specifically, a €20/tCO_2 tax is considered because that is the average price of carbon one may expect in the second ETS trading period (2008-2012).

In 2004, the Irish Government was close to levying a carbon tax, but eventually abandoned the plan due to concerns about the potential impacts on household income and firms' international competitiveness – the two arguments typically brought up against carbon taxes. Yet, only three years later, the carbon levy again entered the agenda, following the strengthening of EU climate policy and the Greens joining the Government. The "Programme for Government 2007-2012" states that "(a)ppropriate fiscal instruments, including a carbon levy, will be phased in on a revenue-neutral basis over the lifetime of this Government". The tax is not there yet, but Budget 2010 is most likely to bring it in.

Any policy involving carbon pricing should include some measures to sustain the households and firms most affected by higher energy prices. All the more so in Ireland, where fuel poverty is a relevant issue (Scott *et al.*, 2008) and the economy is one of the most open in the world. As reported above, the Government is supposed to phase in a carbon tax on a revenue-neutral

[3] A CO_2 tax is typically specified per metric tonne of CO_2 emitted (€/tCO_2). A tonne of carbon corresponds to 3.67 tonnes of CO_2. A carbon tax *strictu sensu* applies to other greenhouse gases as well.

basis, which means other taxes will be cut keeping total State revenues unchanged, or net public spending will stay the same. The whole fiscal reform, depending on existing taxes and distortions in the labour and capital markets, will determine the ultimate outcome of the tax (Fullerton and Metcalf, 2001).

This study focuses on the distributional implications of a €20/tCO_2 tax in Ireland. Microdata from the 2005 Household Budget Survey (HBS) are used to estimate the burden of the levy across the population. In first place, the aim is to establish whether a carbon tax would be regressive, that is, whether it would hit the poor relatively more than the wealthy, and to what extent. The model allows for the increases in both fuel prices and the general cost of living, for which environmentally extended input-output analysis is used. Subsequently, the results are combined with simulations of a most detailed tax-benefit model – the *SWITCH* model of the Irish Economic and Social Research Institute (ESRI) – to compare three tax revenue recycling options for re-balancing the household income distribution. The scenarios envisaged compound increases in income tax credit and welfare payments as well as a cut in the lowest band income tax rate.

The paper is structured as follows. Section II reviews the relevant literature, with a focus on the studies that regard Ireland. Section III illustrates the methodology and data used. Section IV shows the results. Section V concludes.

II LITERATURE REVIEW

The impact of carbon/energy taxes on household income distribution has been investigated in a number of studies. Most of these refer to developed economies, where green taxation has been used, or at least considered, more extensively and consumption of CO_2 related fuels is more even across the population, which fact is at the root of the equity problem. In fact, the literature suggests that carbon/energy taxes generally are, or are expected to be, regressive in developed economies and progressive in developing economies.[4]

As concerns methodologies, partial equilibrium analysis is the standard approach, although, in fact, the supply side is seldom considered. Data on household consumption are used to model household demand and thereby

[4] This can be explained not only by the difference in household expenditure patterns. Shah and Larsen (1992) argue that "… (in developing countries) factors such as market power, price controls, import quotas, rationed foreign exchange, the presence of black markets, tax evasion and urban-rural migration may cast doubt on the regressivity of environmental policies."

estimate the distributional impact of the tax. Also, the analysis can be confined to final demand of fuels, the "direct impact", or include all goods and services to capture the "indirect impact" too. In the latter case, environmentally extended input-output analysis generally is used, with the assumption that the tax is fully translated into final prices. Moreover, among the most recent works, there are few using computational general equilibrium (CGE) models, with disaggregated households. These models enable wider analysis and are best suited to assessing alternative revenue-recycling options.

Among the earliest studies is one by Poterba (1991), who analyses the distributional effect of a gasoline tax in the US. Using the data from the US Consumer's Expenditure Survey, Poterba (1991) calculates the fractions of household income and expenditure that are devoted to gasoline purchase. He concludes that the tax is only slightly regressive, especially when expressed as a share of expenditure. On the other hand, Safirova *et al*. (2004) find that the burden of congestion falls disproportionally on the rich (in and around Washington, DC), so that road pricing or fuel taxation would be strongly regressive.

With a view to the project of a European carbon tax, Pearson and Smith (1991) estimate the distributional impact in seven European countries, namely France, Germany, Italy, Netherlands, Spain, the UK and Ireland. Augmenting Poterba's approach by including price elasticities (although they do not estimate any demand system), they find that in the first five countries the tax would be weakly regressive, while it would be significantly regressive in the UK and strongly regressive in Ireland. Using a more comprehensive model (the E3ME model, a sectoral, regionalised, econometric model of the EU), Barker and Köhler (1998) upgrade Pearson and Smith's work and draw similar conclusions.

Hamilton and Cameron (1994) estimate the distributional impact of a carbon tax in Canada. By means of a CGE model, the authors first determine the tax that would bring about a given cut in CO_2 emissions; they then use input-output analysis to translate the tax into all consumer prices and finally apply a micro-simulation model to assess the impact of induced price changes. It turns out that the tax would be moderately regressive. Similarly, Cornwell and Creedy (1996) investigate the distributional impact of a carbon tax in Australia. The combination of micro-data on household consumption and input-output analysis suggests the tax would be regressive.

A few more studies have been conducted with reference to European economies. Labandeira and Labeaga (1999) explore the effect of a carbon tax on Spanish household income. The authors use input-output analysis to estimate price changes and then simulate consumer response via an Almost Ideal Demand System (AIDS), estimated with data from the Spanish

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Household Expenditure Survey. In contrast with other studies (in addition to those previously mentioned, see Symons *et al.*, 2000), they do not find that a carbon tax in Spain would be regressive.

Tiezzi (2001) simulates the welfare effects of the carbon tax implemented – *de facto* only for one year – in Italy in 1999. Such effects are calculated combining True Cost of Living Indices and Compensating Variation; the parameters are obtained through estimation of an AIDS with household consumption data. The Italian carbon tax is found not to be regressive, since it mainly hits motor fuels and less domestic fuels. Indeed, in developed economies consumption of motor fuels typically increases with income while that of domestic fuels is even across the population.

Brannlund and Nordstrom (2004) analyse welfare effects of changes in green fiscal policy in Sweden, where a carbon tax was introduced in 1991. They first estimate an econometric model for demand of non-durables (a quadratic AIDS), then assume a doubling of the existing tax and finally compare two revenue-recycling options: lower general VAT and lower VAT on public transport (equivalent to a subsidy to that sector). Both reforms end up being regressive, but the second one also has a regional distributional effect, as households in less populated areas would carry a larger share of the tax burden.

Wier *et al.* (2005) assess the distributional impact of the Danish carbon tax, which was first introduced in 1992. The methodology is standard, but nicely incorporates price changes and substitution effects induced by the tax. The latter is found to be regressive, particularly to the disadvantage of rural households. Still using standard methodology, Kerkhof *et al.* (2008) extend the analysis to taxation of other GHGs – all those regulated under the Kyoto Protocol – and find that multiple taxation not only improves the cost-effectiveness of reducing emissions, but also distributes the tax burden more equally across income groups as compared to a carbon tax on its own. This contribution proves particularly relevant for Ireland, where CH_4 accounts for about one-third of total GHG emissions.

Results in the recent CGE literature confirm that the distributional impact of a carbon tax crucially depends on how the revenue is used. In a study applied to the Susquehanna River Basin (a region of the US), Oladosu and Rose (2007) find that a carbon tax would be progressive, since changes in the structure of the economy, higher transfer payments and reduced profits more than offset the regressive direct effects. Yusuf and Resosudamo (2007) find that a carbon tax on its own would be progressive in Indonesia and revenue-recycling through uniform cut in commodity tax rate would reduce the adverse effect on GDP. Particularly encouraging are the results of a study applied to South Africa, as Van Heerden *et al.* (2006) find a "triple dividend" for selected ecological tax reforms: certain mixes of increased energy taxes and reduced food taxes reduce emissions, increase economic output, and reduce the income gap between rich and poor.

Finally, there are at least five studies addressing the distributional effects of a carbon tax with specific reference to Ireland. On the basis of data from the Irish Household Budget Survey (HBS), Scott (1992) predicts that a carbon tax would be markedly regressive in Ireland, because low income households both spend disproportionately more on energy and generally use fuels with higher carbon contents. Scott and Eakins (2004) essentially repeat the work with more recent data and get similar results. O'Donoghue (1997) estimates both direct and indirect impacts, by using HBS and input-output analysis, and it turns out that the tax burden would be borne more equally by households once the indirect impact is taken into account too. Bergin *et al*. (2004) use an energy-augmented macro-econometric model (ESRI's *HERMES* model) to forecast energy demand and emissions, with carbon taxation. In relation to the equity issue, the authors argue that reducing VAT through tax revenue-recycling is better than by giving households lump-sum payments because it would affect competitiveness less. Callan *et al*. (2009) use more recent data than do Scott and Eakins, and combine estimated carbon tax payments with ESRI's micro-simulation tax-benefit model (the *SWITCH* model) to compare a few revenue-recycling options. They find that a carbon tax on its own would be regressive, as expected, and the preferable way to compensate households would be through modest increases in both welfare payments and tax credit. Note that the paper by Callan *et al.,* is in the essence, very similar to the present one. However, the current paper also estimates the indirect impact of the tax,[5] something that Callan *et al.,* did not.

III METHODOLOGY AND DATA

Like the standard literature, this study distinguishes between direct and indirect impacts of carbon taxation on household income. The direct impact is here defined as the increase in fuel expenditure due to higher fuel prices, as opposed to the indirect impact, which is the increase in total expenditure (all goods and services but fuels) induced by higher fuel prices. Microdata from the 2005 HBS are used to estimate the two impacts across the household population. However, estimation of the change in the cost of living also

[5] As said above, O'Donoghue (1997) estimates the indirect impact of a carbon tax in Ireland too, but using older and aggregated (decile level) household consumption data. Also, he does not deal with revenue recycling.

requires the use of Ireland's input-output table as well as data of sectoral emissions. The resulting changes in the household income distribution are then combined with simulations of the *SWITCH* tax-benefit model to evaluate three alternative tax revenue recycling options. Note that all population estimates based on the HBS are obtained by applying HBS household specific grossing-up factors. Also, the *SWITCH* model automatically grosses-up the survey data it is based on.

There follows a detailed illustration of the three-step analysis sketched: direct impact of the tax, indirect impact and revenue recycling.

3.1 Estimating the Direct Impact

Microdata from the 2005 HBS (CSO, 2007) are used to calculate household fuel consumption and related CO_2 emissions. The fuels included in the HBS are considered either "home fuels" (gas, electricity, anthracite, coal, turf, turf briquettes, central heating oil, paraffin oil and LPG) or "motor fuels" (petrol, diesel and LPG auto). Since only expenditure on motor fuels is reported in the HBS, quantities of petrol, diesel and LPG auto are derived dividing expenditure by price.[6] Thus, for each household in the sample, weekly fuel quantities are translated into energy (Tonnes of Oil Equivalent (TOE)) and, in turn, into weekly CO_2 emissions, by using standard calorific values and emission coefficients[7] respectively. Finally, weekly[8] tax payments are estimated by applying the assumed €20/tCO_2 tax to emissions so derived.

The method hinges on two important but standard assumptions: (1) fuel prices increase by an amount equal to the tax (i.e. producers entirely shift the tax onto the consumer); (2) consumers do not switch to cleaner fuels when the tax is levied (i.e. zero demand price elasticities). However, we know that in reality the tax pass-through depends on the specific market structures, which are not investigated in this study. Also, we know zero price elasticities are plausible in the very short run, but not over a longer horizon. In light of that, the estimation results can best be interpreted either as first round effects or the "worst case" for consumers.

3.2 Estimating the Indirect Impact

The same HBS dataset is used to calculate household consumption of all goods and services other than fuels. However, standard emission coefficients for general consumption do not exist and, hence, have to be derived. O'Doherty

[6] The prices prevailing (quarter averages) at the time the survey was taken are applied. The source for data of fuel prices are Sustainable Energy Ireland (petrol and diesel) and Flogas (for LPG auto).

[7] Calorific values and emission coefficients used are reported in Table A1, in the Appendix.

[8] In the HBS, consumption data are by week. In fact, they are averages over two successive weeks.

and Tol (2007) provide the theoretical framework for the purpose.

In the standard input-output model, with $i = 1,2,\ldots,n$ output sectors and $j = 1,2,\ldots,n$ input sectors, production **X** depends on final demand **Y**, through the Leontief matrix **L**:

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\,\mathbf{Y} = \mathbf{LY} \tag{1}$$

where **A** is the matrix $a_{ij} = X_{ij}/X_j$.

If sectoral CO_2 emissions (allocated by gas production) are given, a model for total emissions M depending on final demand is obtained by first defining

$$M = \mathbf{BX} \tag{2}$$

where **B** is the vector of "production coefficients", that is, emissions per unit of production (grams/€), and then combining (2) with (1)

$$M = \mathbf{BLY} \tag{3}$$

where **BL** is therefore the vector of "consumption coefficients", that is, emission per unit of consumption (grams/€).

Ireland's 2005 input-output table (CSO, 2009) is used. The model comprises 19 NACE[9] sectors (NACE19) because this is the the most disaggregated level for which data of sectoral output and emissions are both available. The NACE19 classification is the following:

1. *Agriculture, fishing and forestry*
2. *Coal, peat, petroleum, metal ores and quarrying*
3. *Food, beverage and tobacco*
4. *Textiles clothing leather and footwear*
5. *Wood and wood products*
6. *Pulp, paper and print prod.*
7. *Chemical prod.*
8. *Rubber and plastic prod.*
9. *Non-metallic mineral prod.*
10. *Metal prod. excl. machinery and transport equipment*
11. *Agricultural and industrial machinery*
12. *Office and data process machines*
13. *Electrical goods*

[9] NACE is the classification of economic activities in the EU.

14. Transport equipment
15. Other manufacturing
16. Fuel, power and water
17. Construction
18. Services (excl. transport)
19. Transport

Production coefficients are calculated using data of sectoral emissions and output published by EPA (2009a) and CS0 (2009), respectively. Subsequently, in order to apply the derived consumption coefficients[10] to HBS demand, the HBS code has to be mapped into NACE19.[11] With the consumption microdata (all goods and services but fuels) aggregated in 19 categories, the corresponding consumption coefficients are applied. The indirect impact of the tax is then estimated multiplying the €20/tCO_2 rate by the emissions so derived. At this point, two remarks are needed. First, since most probably only domestic production would be subject to the carbon levy and since the HBS does not specify the origin of the goods and services purchased, consumption coefficients only apply to the share of household demand which is satisfied by domestic production. For example, since 20 per cent of "Rubber and plastic" demanded by households is imported, the corresponding consumption coefficient applies only to 80 per cent of HBS households' expenditures on "Rubber and plastic".[12] Second, since it is assumed the tax will apply only to the non-ETS sector, the emissions from the activities covered by the EU ETS should not be considered in the determination of the indirect impact of the tax. To take account of this, production coefficients of the sectors corresponding to the EU ETS activities (i.e. 6, 9, 10 and 16 in NACE19) are set equal to zero.

Finally, the method for estimating the indirect impact of the tax is based on a few relevant assumptions: 1) all producers shift the tax downhill, which implies the consumer bears the whole burden of the tax; 2) producers do not switch to less carbon intensive fuels after the tax is levied (i.e. zero supply price elasticities); and 3) consumers do not substitute domestic with imported products (i.e. zero demand price elasticities). Thus, again, in light of these restrictions, the estimation results can best be interpreted either as first round effects or the worst possible scenario for consumers.

[10] Both production and consumption coefficients for 2005 are reported in the Appendix (Table A2).
[11] The mapping code is not reported to economise on space, but it can be requested from the authors.
[12] The shares of imports on final household demand, by NACE19 sector, are reported in Table A3, in the Appendix.

3.3 Recycling the Revenue

The *SWITCH* model is regularly used by the Department of Finance for distributional analysis of the impact of the annual budget. It is a model of direct taxes and welfare payments, based on the Survey on Income and Living Conditions (EU SILC, CSO, 2006) – a nationally representative survey capturing the variability in the household population across age, household composition, income, employment, and disability. Here, it is used to analyse the distributional implications of tax revenue recycling.

Income taxes in Ireland are relatively straightforward. A 20 per cent tax is paid on income below €35,400 per year. Above that, a tax of 41 per cent is paid. There is a standard tax credit of €3,660, so that the first €18,300 earned is essentially tax-free. There are additional tax credits for mortgage and rent, for family circumstances, and for disabilities. The Irish benefit system is considerably more complex, with income supplements, child benefits, maternity and homemaker benefits, carers benefits, illness and disability benefits, jobseeker and training benefits, pre-retirement allowances and pensions; many of these benefits come in both an entitlement and a means-tested mode.

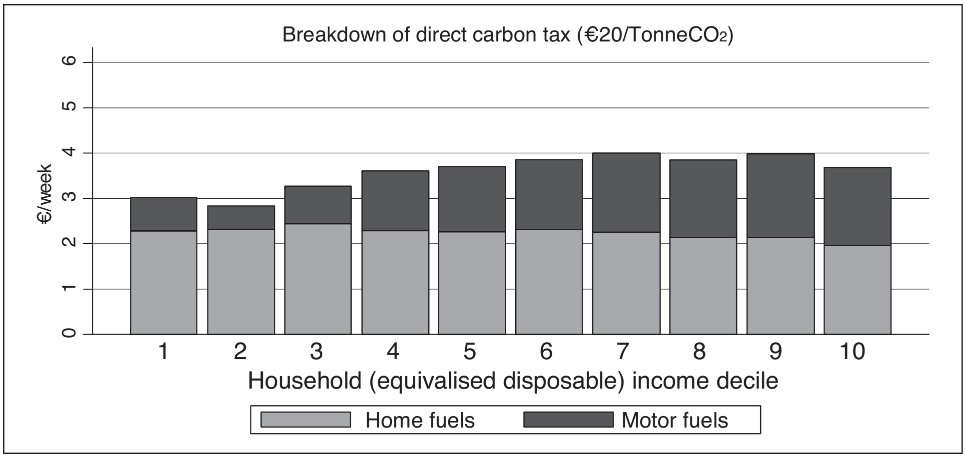
The *SWITCH* model is used to simulate three revenue-recycling options. Specifically, both the first and second scenarios involve a €2 increase per week in all social welfare payments (pensions, unemployment compensation, short-term illness and long-term disability, one parent families) and a €104 increase per year in basic personal tax credit. The second scenario only differs for one additional measure, namely a €0.8 payment per week for each qualifying child of a social welfare recipient. The third scenario hinges on income taxation. It still provides for the €2 increase in all social welfare payments, which is obviously a measure for reaching low income households, and adds a half percentage point cut of the lowest band income tax rate, that is, from 20 per cent to 19.5 per cent.

IV RESULTS

4.1 Direct Impact

It emerges from the data that emissions associated with energy consumption for heating and cooking (home fuels) are virtually constant across the household population. Hence, the same pattern is derived for the related tax payments. Conversely, emissions caused by private transport are increasing with income and, again, the same pattern must apply for the tax payments on consumption of motor fuels. The overall direct impact of the tax is estimated to range across the household distribution between €3 and €4 per week, of which about €2 are invariably against consumption of home fuels (Figure 1).

Figure 1: *The Direct Impact of the Tax*



Note that: (1) emissions and related tax payments for electricity consumption are not considered; and (2) households are sorted by equivalised disposable income.[13] This is the case because: (1) electricity generation is regulated under the EU ETS and price increases of electricity have already been included in the relevant price indices that are used for setting benefits and in wage negotiations; and (2) equivalised disposable income is deemed a better measure of real wealth.

HBS data on energy consumption at home (electricity included) also reveal some facts that are relevant for climate policy and, hence, worth pointing out here. Equivalised energy consumption, measured by "TOE per adult equivalent", is lower for the middle deciles and higher at the edges of the household income distribution. One may assume that this is so because dwellings of low income households are not well insulated, while high income households use more energy and do it more efficiently too (O'Doherty *et al.,* 2008). This hypothesis seems to be supported by the fact that, for low income deciles, the percentage of dwellings with double glazing is negatively correlated with energy consumption.[14] Moreover, as stressed in previous

[13] Equivalisation corrects for the size of households by expressing household income as income per adult equivalent. The weights used are: "head of household" = 1; "other adults" = .66; "children (<14)" = .33.
[14] Unfortunately, data on roof-insulation are not available in the HBS.

studies, low income households in Ireland usually make more extensive use of cheaper but more carbon intensive fuels, such as coal and turf. The ratio "Emissions per TOE", measuring the carbon intensity of a mix of fuels, indeed is found to be strongly correlated with income. It so happens that (equivalised) emissions due to heating and cooking are exactly the same for the first and tenth deciles, but energy consumption is higher in the latter. Figures (weekly energy and emissions data) are reported in Table 1.

Table 1: *Home Energy Consumption and Double Glazing; Home Fuels Carbon Intensity and CO_2 Emissions*

Income Decile	*Energy TOE eq.*	*Efficiency Double Glazing (%)*	*Fuels tCO_2/TOE*	*Emissions tCO_2, Equivalised*	*Emissions tCO_2*
1	.022	67	4.50	.091	.161
2	.029	60	4.51	.115	.163
3	.026	66	4.37	.103	.170
4	.020	75	4.37	.081	.171
5	.020	77	4.40	.082	.175
6	.021	79	4.21	.084	.177
7	.021	82	4.17	.084	.175
8	.022	83	4.21	.082	.169
9	.024	84	4.15	.092	.168
10	.025	82	4.01	.091	.158

Thus, poor insulation and more extensive use of carbon intensive fuels seem to explain why, at home, low income households are responsible for as much, or slightly more, emissions as high income households. However, variability within deciles is quite high. Further investigation with the use of econometrics could certainly reveal more about the relations highlighted, but that would be beyond the scope of this study.

4.2 Indirect Impact

As expected, the indirect impact of the tax turns out to be increasing with the level of income. Specifically, under the assumption that a €20/Ton of CO_2 tax is levied only in the non-ETS sector, and not on imports, the burden of the tax sums to less than €0.5 per week for the first decile and rises up to €1.5 for the tenth. However, if the tax is made to apply to imports as well,[15] the cost of living increases more significantly along the household income distribution

[15] Note that, in fact, if the tax was levied on imports too, the price of carbon in the exporting country would be considered (i.e. a €20 rate would be applied only to imports from countries where the price of carbon is zero, whereas a lower rate would be applied to imports from a country where the price of carbon is positive). Also, it is implicitly assumed that carbon intensities of production processes in exporting countries are the same as in Ireland.

(around €1 for the first decile, €2.5 for the tenth). This shows that Ireland is responsible for substantial (relative to domestic) CO_2 emissions abroad. Similar results are obtained if the tax is levied in the ETS sector too, but not on imports. Finally, the increase in the cost of living is substantially higher (three times as much as in the first scenario), if the tax applies to both the ETS sector and imports. Figure 2 shows these results.

Figure 2: *The Indirect Impact of the Tax Under Three Different Scenarios*

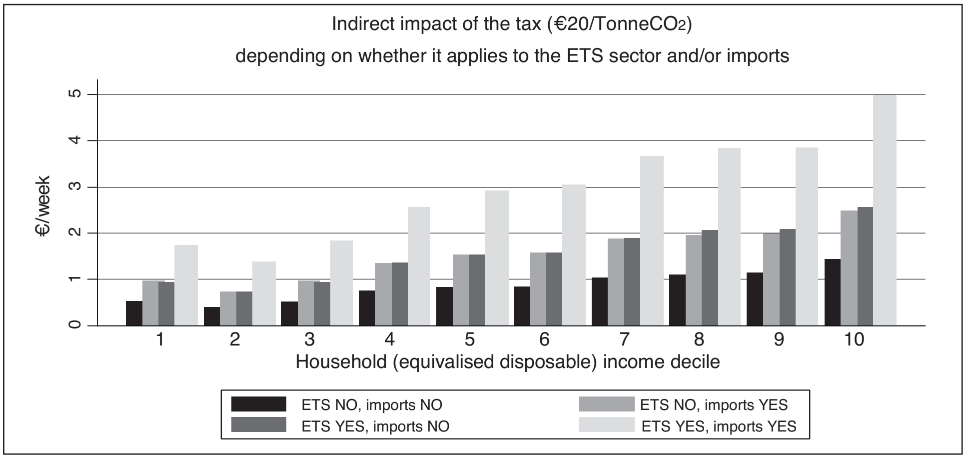
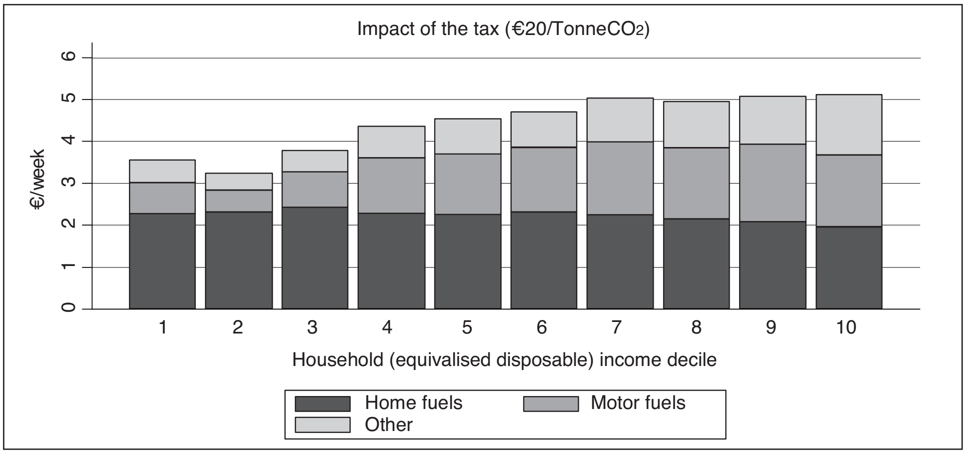


Figure 3 shows the overall impact of the tax, given by the sum of direct and indirect impacts, under the assumption that the tax applies neither to the ETS sector nor to imports. As argued previously, the latter scenario is indeed the most likely and recommendable for Ireland.

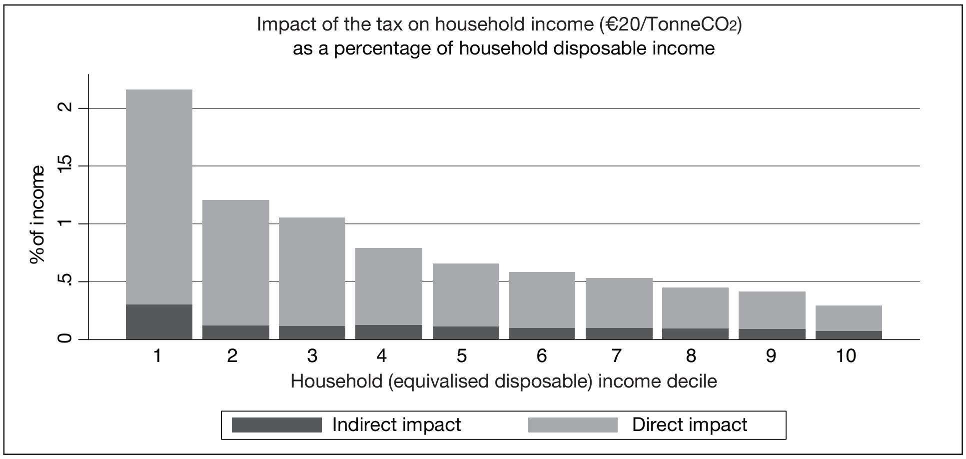
Figure 3: *The Overall Impact of the Tax*



4.3 Tax Regressiveness

The regressiveness of the tax here is measured as the ratio between estimated tax payments and household disposable income. In line with the literature specific to Ireland, the carbon tax is markedly regressive as expected: the impact in the first decile is seven times as big as that in the tenth decile (see Figure 4). Behind this result is the pattern of direct energy consumption, which is virtually flat across the income distribution.[16]

Figure 4: *Tax Regressiveness*



Most important, average tax payments exceed 2 per cent of disposable income for the poorest decile. Also, variability within the first decile is very high (the coefficient of variation is four times bigger than in the other deciles) and the distribution strongly skewed: only 24 per cent of households in the decile have an impact higher than the decile average. This implies that 2.4 per cent of Irish households would suffer an impact higher than 2 per cent, and, in fact, some of them would suffer impacts way higher than that. Yet, a more careful look at the data reveals that errors in income data are most likely, at least for some of the observations with extremely high impact.

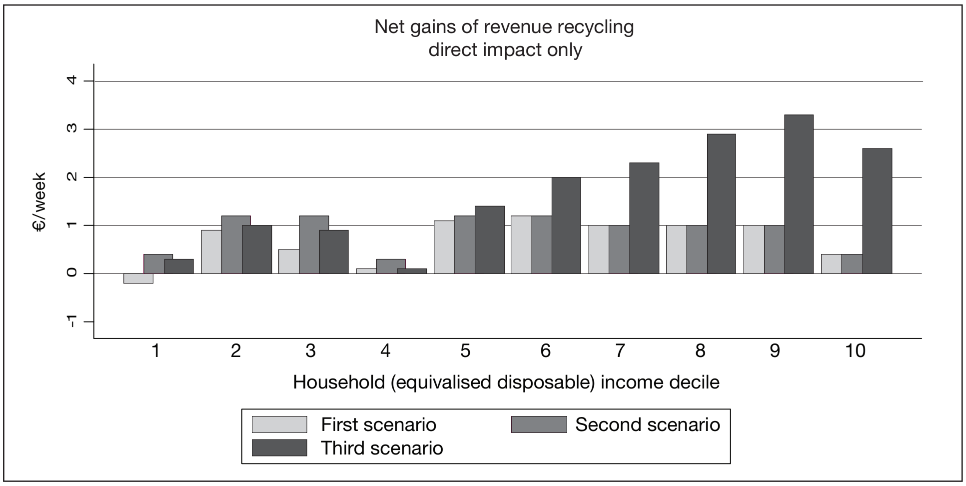
4.4 Recycling the Revenue

Figure 5 compares the average net gains associated with the three revenue recycling options considered in this study, when allowing for the compensation of the direct impact only. In the first scenario, the increase in social welfare payments benefits households in the lower deciles, whereas the

[16] Interestingly, Wier *Molly.* (2005) find very similar results for Denmark, though less regressive overall.

increased tax credit benefits households in the upper half. Net gains are minimal for deciles 1 (in fact, no gain), 4 and 10. The second option, or scenario, only adds an increase in the qualified child allowance for social welfare recipients, which fact has clear benefits for the lower incomes. As for the third option, i.e. higher benefits and lower tax rate, there are relevant gains across the income distribution, but minimal ones for deciles 1 and 4. Rich households definitely gain more under this scenario.

Figure 5: *Tax Revenue Recycling: Compensating the Direct Impact of the Tax*



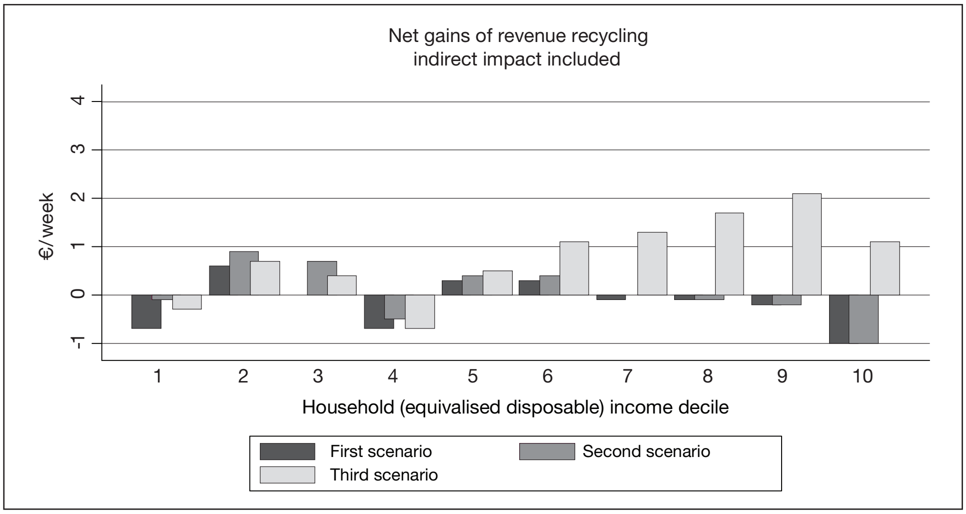
No doubt, the second scenario is preferable: it improves the first one, which generates negative gains for the first decile, while distributing gains over the deciles more equitably than the third. Moreover, the cost of the second scenario would be €360 million, as compared to €423 million for the third scenario. Conefrey *et al.* (2008) estimate a €20/tCO_2 tax to generate, in 2010, a revenue stream of about €550 million from the non-ETS sector.[17] Therefore, under the second scenario, there would be a substantial amount of money left over after households' compensation (€190 million).

Should the government compensate households for the indirect impact of the tax too? Arguably, it should not. The indirect impact, as previously defined, is largely felt as a general increase in prices, which fact has two types of implications: (1) it is supposed to be included already in inflation adjustments of benefits and wages; (2) compensation for the indirect impact would not drive consumer behaviour towards less carbon intensive consumption anyway.

[17] Note that the €550 million estimate allows for the substitution effects induced by the tax.

Therefore, the tax is likely to be more effective if the revenue destined for the compensation of the higher cost of living is actually used for other purposes. Yet, it is still interesting to compare our three revenue recycling options once again, this time allowing for the indirect impact of the tax as well (Figure 6). Note that the latter refers to the case the tax is levied only in the non-ETS sector, and not on imports: net gains are somewhat lower if tax is levied also in the ETS sector and/or on imports.

Figure 6: *Tax Revenue Recycling: Compensating the Indirect Impact Too*



Most importantly, 55,000 households (equivalent to 3.8 per cent of the total), according to the *SWITCH* estimates, would not be assisted by the tax/welfare compensation packages here considered. Some of these households would be households with a low self-employment income, subject neither to tax nor eligible for social welfare payments. This is a very serious issue, which, if anything, should be solved for other reasons than climate policy.

V CONCLUSIONS

In view of the emissions target for 2020, Ireland needs major cuts in GHG emissions from the non-ETS sector. Accordingly, the government is supposed to introduce a carbon tax, which: (1) would be revenue-neutral; (2) should be levied only in the non-ETS sector; and (3) should be close to EU ETS price of carbon. This paper analyses the distributional implications of a €20/tCO_2 tax with such characteristics.

The direct impact of the tax is estimated to range between €3 and €4 per week, per household, across the household population. In line with findings of previous work on Ireland, household energy consumption for heating and cooking is virtually constant across the household population, while consumption of motor fuels is positively related to income. Importantly, there is evidence that, at home, low income households are less energy efficient and rely more on carbon intensive fuels (both facts result in higher tax payments). Besides, note that emissions from Transport and Residential sectors have been growing faster than in the other sectors of the economy over the last few years. That is why a carbon tax in the non-ETS sector is needed.

The indirect impact of the tax is estimated to range between €0.5 and €1.5 per week, per household, across the household population. Since the indirect impact relates to consumption of all goods and services but fuels, it is increasing with income. The increase in the cost of living would be more significant, though still limited, if the tax was applied to imports and/or the ETS sector. However, both circumstances are most unlikely, as taxing imports from countries with more loose carbon restrictions would be technically difficult and levying the tax in the ETS sector is not expedient (carbon leakage).

The overall impact of the carbon tax is markedly regressive, as the average burden is an estimated 2.1 per cent of disposable income for the first decile, 1.2 per cent for the second decile and 0.3 per cent for the tenth decile. Yet, the impact distribution is strongly skewed within the first decile, which fact implies the burden would be smaller than 2.1 per cent for most of the households in the decile and much higher than that for a few households (though still a significant number). Moreover, a few of the observations with highest impacts are found to have spurious income values (making the impact huge) and the tax would probably be less regressive if compared to consumption rather than disposable income.

Three alternative welfare/tax packages for compensating households were simulated. A €2 increase per week in all welfare payments, a €104 increase per year in tax credit and a €0.8 payment per week for each child of social welfare recipients, turns out to be the mix of measures distributing net gains most equitably, while leaving over substantial resources to finance other programmes. Specifically, some €190 million would be left over and one may consider it only costs about €1,000 to install attic or wall cavity insulation in a home (Ryan *et al*., 2008).

Overall, the results of this study suggest that distributional concerns should not deter the introduction of a carbon tax in Ireland. Above all, it should be emphasised that all estimates of the tax impact on household income are conservative because the methodology used allows for substitution effects neither on the supply nor the demand side of the economy and the burden of the tax is entirely borne by consumers too. Yet, even so, on average households are better off after revenue recycling and substantial resources are left over too. Also, low income households have wider margins for carbon reductions, to be achieved through the use of less carbon intensive fuels and energy efficiency.

The levy of a carbon tax may have further distributional implications through the labour market. Therefore, the use of a general equilibrium approach is a necessary extension of the present study. A general equilibrium approach would also enable the analysis of the tax impact on other relevant economic measures, such as economic growth and international competitiveness. In relation to the latter, the restrictions on CO_2 put in place in Ireland's most important trading partners should be taken into account as well.

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APPENDIX

Table A1: *Calorific Values and Emission Coefficients*

Fuel	*HBS Measure*	*Calorific Value (TOE)*	*Emission Coefficient (tCO_2/TOE)*
Gas	Kwh	.000086	2.378
Electricity	Kwh	.000086	7.402 (year 2006)
Anthracite	Kg	.000665	4.110
Coal	Kg	.000665	3.961
Turf Loose	Cwt	.015907	4.354
Turf Briquettes	Bale	.005538	4.137
Central Heating Oil	Litre	.000868	3.050
Paraffin Oil	Pint	.000473	2.980
LPG	Kg	.001126	2.667
Petrol	Litre	.000804	2.931
Diesel	Litre	.000874	3.050
LPG auto	Litre	.000563	2.670

Table A2: *2005 Production and Consumption Coefficients (Grams/€)*

NACE19	*With Tax in the ETS*		*Without Tax in the ETS*	
sector	*Production*	*Consumption*	*Production*	*Consumption*
1	120	293	120	184
2	41	170	41	77
3	65	285	65	173
4	176	309	176	224
5	49	52	49	51
6	6	33	0	9
7	18	29	18	21
8	32	760	32	191
9	1925	2105	0	44
10	572	1035	0	68
11	35	213	35	73
12	16	38	16	21
13	13	89	13	43
14	31	409	31	122
15	179	304	179	234
16	3436	4429	0	23
17	11	14	11	11
18	14	129	14	53
19	1047	1319	1047	1200

Table A3: *2005 Household Demand: Imports*

NACE19 Sector	*Household Demand: Imports (%)*
1	46.7
2	36.6
3	51.9
4	95.7
5	43.0
6	54.7
7	90.3
8	67.8
9	77.0
10	27.3
11	89.3
12	96.1
13	82.9
14	96.4
15	67.9
16	0.5
17	0.0
18	4.4
19	9.1