I would like to begin by thanking An Cathaoirleach and the Committee for the invitation to appear today. My name is Muireann Lynch of the Energy Economics team in the ESRI and I am accompanied by Dr Kelly de Bruin of the Climate Economics team.

The brief for today's meeting concerns energy poverty and has three subparts. I would like to address the first two together.

Defining and measuring energy poverty, and the impact of increased carbon taxation

(1) Review of the most appropriate measure of, and the extent and nature of fuel poverty across all cohorts.

(2) The short, medium and long- term impact on fuel poverty of the options for increasing the carbon tax

The appropriate measurement of fuel poverty is not a settled question in the literature. There are generally three distinct definitions:

A) The first definition considers a household to be experiencing fuel poverty if they spend more than a certain percentage of their total income on fuel. This percentage is typically set at ten percent of net income excluding housing costs, and this definition has been adopted by the Department of Communications, Climate Action and Environment.
B) The second measurement considers modelled rather than actual spend. In other words, the expenditure on fuel that would be required to achieve an adequate temperature is determined, taking into account household and dwelling characteristics. The household is again considered to experience fuel poverty if this expenditure is above a certain percentage of total household income.
C) The third metric relies on self-reported subjective data, and categorises a household as experiencing fuel poverty if they have difficulty affording adequate heating or fuel.

At this point, I would like to note that these definitions pertain to household thermal energy expenditure only, and do not consider costs of private or public transportation.

Choosing an appropriate measurement of fuel poverty from the three above is not straightforward and the reasons for this are perhaps best explained by means of a simple example considering a carbon taxation increase (part (2) of the Committee's brief), as well as considering the eleven Indicators of Basic Deprivation, the full list of which I have provided as an Appendix to this Statement. A household is considered to be experiencing Basic Deprivation if they are unable to afford two or more of the eleven items. I would like to stress at this point that the figures chosen here are purely indicative.

The Murphy household is a low-income household that currently spends just below ten per cent of their income net of housing costs on fuel. They live in a poorly insulated house and have a low efficiency gas boiler for central heating. They cannot afford one of the eleven indicators of basic deprivation, meaning they are not currently considered to be experiencing basic deprivation.

Carbon taxation is increased by some quantum which means that, assuming the Murphys make no change whatsoever to their behaviour, their energy bills increase by €200 per year. The Murphy household includes a small baby and an elderly relative, and so reducing the extent to which they use their central heating is not an option. Therefore, they continue to heat their house as normal, and are now considered to be experiencing fuel poverty under criterion (A), which relates to actual fuel expenditure, and under criterion (B), which relates to modelled necessary fuel expenditure. They can, however, "afford" their energy costs, and so are not considered to be experiencing fuel poverty under criterion (C), which relates to self-reported ability to afford fuel. In order to afford the increase in their energy bill, the Murphys reduce expenditure on social activities and put off replacing worn out furniture, so they are now considered to be experiencing basic deprivation, as they now cannot afford two or more of the eleven indicators. Assuming fuel and carbon prices continue to rise, this effect will hold in the short and long run.

Suppose instead that the Murphy household consists of a couple with teenagers. They decide to reduce the extent to which they use their central heating by turning off the heating in the morning, leaving the house earlier and eating breakfast at work or school rather than at home. Here the Murphy household does not qualify as experiencing energy poverty under criterion (A), but does qualify under criteria (B) and (C). They are also now considered to be experiencing basic deprivation (as inability to keep the house adequately warm is one of the eleven items that indicate basic deprivation). This holds in the short and long run.

Finally assume the Murphys take out a loan of €2000 from the Credit Union to buy a new more efficient boiler, that reduces their annual energy bills by €300. They repay this loan at a rate of €21 per week over the next two years, and again pay for this loan by reducing their expenditure on social activities and they put off replacing worn out furniture. In this scenario, the Murphys do not qualify as experiencing fuel poverty under any of the three criteria. They are, however, considered to be experiencing basic deprivation, for the next two years. In the long run, once they have paid off the loan, they do not qualify as experiencing either fuel poverty or basic deprivation, under any definition.

ESRI research on energy poverty

Notwithstanding the difficulties associated with measuring fuel poverty, several pieces of ESRI research have considered this question. At this point I would like to draw attention to two of the more recent papers. Roantree and Bercholz (2019) estimated the impact of an increase in carbon taxation on fuel poverty, using definition (A) above. They found that increasing carbon taxation from €20 to €30 per tonne increases the percentage of households spending more than 10% of their income on heating from 17.4% to 18.1%. They also found, however, that according to the self-reported definition of energy poverty, definition (C) above, only 8.7% of households are considered to be experiencing energy poverty. This highlights the sensitivity of fuel poverty policy to the definition chosen.

The second piece of research I would like to mention at this point is by Watson and Maitre (2015). They analysed data from the indicators of basic deprivation, and found that energy poverty is not a distinct type of deprivation. In other words, households that experience basic deprivation and households that experience fuel poverty are one and the same. In order to target households in fuel poverty, it is sufficient to target households in poverty. The illustrative examples of the Murphys above should go some way to explaining this result: poverty is a problem of limited resources. A family with insufficient resources to achieve an adequate standard of living must decide where to prioritise expenditure, and different families will have different priorities. Given the difficulties associated with defining and measuring fuel poverty, a policy that seeks to mitigate the impact of carbon taxation on *poverty* will therefore perform at least as well as a policy that seeks to mitigate the impact of carbon taxation on *fuel poverty*, and may well do better.

Protecting those on low incomes

This brings me to the third subpart of the Committee's brief, how to protect those on low incomes. There are several recent pieces of ESRI research on this topic, the aforementioned paper by Roantree and Bercholz, a paper by myself and Dr Miguel Tovar Reaños, and several pieces of work by Dr de Bruin and her colleagues. They use different datasets and methodologies, but the broad conclusions are similar. I have attached a detailed summary of the three pieces of work as an Appendix to this Statement. The main results agree that, as is the case in all high-income countries, increasing carbon taxation is regressive, which means that less affluent households would pay more in carbon tax, as a proportion of their total income, than the most affluent households. However, all three pieces of research have found that these impacts can be reversed by recycling the revenues raised from carbon taxation back to households. While these papers do not specifically consider the impact on fuel poverty, we find several ways of recycling carbon taxation revenues that leave the poorest cohorts of households better off. These cohorts naturally include those experiencing energy poverty.

Different recycling mechanisms have different impacts. Roantree and Bercholz find that giving every household an equal share of revenues makes every income decile better off, with the lowest income decile experiencing the greatest proportional increase in income. However, 23% of households, across all deciles, are worse off, even after compensation, including 21% of the households in the lowest income deciles. If we recycle the revenues to households through increasing tax credits and social welfare payments, rather than via a lump sum, all income deciles are also rendered better off on average.

Similar findings are made by myself and Miguel Tovar Reaños. In addition, we examined the impact on total income inequality, and found that combining carbon taxation with revenue recycling actually reduces income inequality, relative to a business as usual scenario. This is in addition to the reduction in carbon emissions that comes about as a result of the tax increase.

Dr de Bruin’s team has analysed the economy-wide impact of carbon taxation and revenue recycling, which takes into account all behavioural and economic impacts. They find that recycling the revenues to households, either through a lump sum or through the social welfare system, mitigates the impact on those on low incomes. Poorest households benefit most when the social welfare system is employed, but all households better off under this policy, with the exception of the highest income cohorts in both urban and rural settings, who experience small declines in income. If instead we recycle the using a combination of income tax cuts and transfers to households, either via a lump sum or via the social welfare system, all households are better off, but richer households gain more than the poorest cohorts.

In conclusion, energy poverty is difficult to measure, and the final determination of the extent and degree of energy poverty is highly sensitive to the definition chosen. However, households experiencing energy poverty are included in the wider set of households experiencing poverty, and therefore the most appropriate policy response may be to consider the impact of increased carbon taxation on poverty, rather than energy poverty. The research is clear that combining carbon taxation with appropriate revenue recycling can render the entire policy initiative progressive, with poorest households being the greatest beneficiaries. Recycling revenues through the taxation and welfare system is therefore an obvious way of protecting low income households.

I’d like to thank you very much again for the opportunity to present this research to you and we would be happy to answer any questions you may have.

Basic Deprivation: cannot afford 2 or more of the following:

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2. A warm waterproof overcoat
3. Buy new (not second-hand) clothes
4. Eat a meal with meat, chicken, fish (or vegetarian equivalent) every second day
5. Have a roast joint or its equivalent once a week
6. Had to go without heating during the last year through lack of money
7. Keep the home adequately warm
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ESRI carbon tax research

Kelly de Bruin & Aykut Mert Yakut

Introduction

Climate change is a key element of the current policy discussion in Ireland. An increase in the Irish carbon tax is an important and extremely relevant policy option to achieve Ireland's emissions targets. Implementing and designing a carbon tax increase and understanding its impacts is a complex issue, where many different aspects need to be considered. Given the importance and complexity of this issue, there are three teams within the ESRI examining the issue of a carbon tax increase. Each body of work applies a different method, each with a unique advantage of answering specific carbon tax related policy questions. This document will discuss these three bodies of work and compare their methods, data and results.

Microsimulation model

One of the most important questions concerning the implementation of an increased carbon tax is how households will respond to this tax increase in terms of their consumption. Consumer responses to energy price increases are complex to model given that different consumers will react very differently to prices given their economic, social and living circumstances. Miquel Tovar Reanos and Murrieann Lynch develop a behavioural microsimulation model, which focusses on modelling households' responses to changes in prices. Consumption decisions are represented as a system of equations which depend on prices, consumption budgets and observed and unobserved characteristics. In this way impacts of different households can be estimated due to their unique characteristics. Consumption goods are grouped into 6 categories: food, housing, heating and lighting, transport, education and leisure, and other goods and services. Consumption switching is represented by changes in the relative shares of these different commodity groups in total consumption. Tovar Reanos and Lynch use 5 Household Budget Survey waves (1994, 1999, 2004, 2009, 2015-2016) to estimate their model.

Their model examines the one time increase of the carbon tax and analyzes the impacts across households given their consumption responses. They find that for a 30 (80) Euro increase in the carbon tax reduces households' direct emissions by 3.9% (10.2%). Without revenue recycling, they find that the carbon tax increase is regressive and inequality increases. Total household expenditure declines by 0.5% for a 30 Euro increase and 1.1% for an 80 Euro increase. To estimate the welfare impact, they estimate the Hicksian Equivalent Variation (HEV), which represents how much the household would need to be compensated for the policy change to be no worse off. They find that the first quantile would need to be compensated 0.88% of their expenditure, the second 0.59%, the third 0.48% and the fourth 0.39% for a 30 Euro increase.

They furthermore investigate the use of revenue recycling to reduce the repressiveness of the carbon tax increase. They examine a 'flat' lumpsum transfer, where carbon tax revenues are shared across households equally. Using revenue recycling redistributes income to poorer households making the first three quantiles better off and decreasing inequality. Moreover, they examine a 'targeted' transfer where carbon tax revenues are shared among household in an inverse proportion to their income, i.e. poorer households receive a higher transfer compared to richer. This further redistributes the income from richer to poorer households with where the first 2 quantiles are significantly better off with the carbon tax increase.

This method is extremely useful in understanding households' responses to a carbon tax increases. Their analysis is limited to households' direct carbon consumption (gasoline, diesel, solid fuels, liquid fuels, natural gas) and does not include carbon tax impacts on the prices of other goods. Furthermore, they do not include secondary price impacts, where for example as carbon tax increases, demand decreases, reducing the price. Consumption changes are represented by changes in consumption of the various commodity categories, e.g. due to a carbon tax energy goods consumption will decrease, however switching between these energy goods is not modelled. Impact on household income through labour and capital income, which is also affected by carbon taxes.

Micro simulation- SWITCH model

Revenue recycling can be paramount in reducing the burden and inequality impacts of a carbon tax. Hence, investigating in a practical sense how revenue recycling can be achieved in the Irish economy via the tax and benefit system is important. Furthermore, a complete understanding of the winners and losers of such a policy is paramount. Bercholz and Roantree apply the SWITCH model to answer these questions.

Bercholz and Roantree include a detailed description of households and examine different households are impacted by a carbon tax increase. They examine as Tovar Reanos and Lynch the impact of a carbon tax increase on the direct consumption of carbon commodities. Unlike, Tovar Reanos and Lynch, they do not include behavioural responses, but examine initial impacts without consumer behavior changes. They apply the ESRI's tax and benefit microsimulation (SWITCH) model, which replicates the tax and benefit system of Ireland in a high level of detail, to simulate different revenue recycling schemes.

Bercholz and Roantree introduce a 10 Euro increase in the carbon tax. As Tovar Reanos and Lynch, they find the tax to be regressive, where the poorest decile has losses of 0.25% of their disposable income and the richest decile of 0.15% of their expenditures. Concerning household types, they find that other, couples with children, couples and retired people are impacted the most in terms of addition costs per week. Bigger households are impacted higher as well as landlord households (as opposed to tenants) and rural households. Due to the detailed representation of households, Bercholz and Roantree can assess impacts on fuel poverty and find a 0.7 percentage point increase in fuel poverty as measure by households spending more than 10% of their income on fuel.

Bercholz and Roantree examine 6 potential packages of carbon tax revenue recycling and their impacts. First, applying a lump-sum rebate, similar to Tovar Reanos and Lynch, they find that the repressiveness of the tax can be turned around. They find that on average households are 0.07% better off, where poorer households gain on average 0.4% and richer 0.02%. However, 23% of households are still worse off within these household groups. This is higher for richer households.

Second, they model a reduction in income tax through an increase in income tax credit. Personal, PAYE, earned income, home carer and widowed tax credit are increased by 3.65%.

This has regressive impacts, where the poorest households will have a loss of more than 0.3% of disposable income, whereas the richest have a gain of 0.1%.
Third, to investigate how lower income households can be compensated, an increase in social welfare benefits is modelled. This is done by increasing the maximum rates of social welfare benefits by 1.35%. This reform has a progressive impact where the lower income households gain 0.6% of disposable income while the richest have losses of almost 0.1%. Finally, Bercholz and Roantree consider a combinations of income tax reduction and social welfare benefit increases.

This method is important in understanding how carbon tax revenues can be recycled using the current Irish tax and benefit system. Furthermore, it can give invaluable insights into the varying impact across households under each recycling method. Bercholz and Roantree examine the direct initial impacts on carbon commodities (gasoline, diesel, solid fuels, liquid fuels, natural gas) and do not consider secondary impacts or impacts on prices of other goods or labour/capital income.

Computable General Equilibrium modelling- I3E

Understanding the secondary and macroeconomic impacts of a carbon tax is of paramount importance in preparing an economy for a transition to low carbon. To understand the secondary impacts, carbon inputs into production processes of various goods needs to be modelled as well as the demand and supply of goods and services. To investigate the macro economic impacts, labour and capital demand and supply need to be considered. This calls for the modelling of households as well as production sectors and capital/labour markets. Finally, to examine policies, the government and existing taxes and transfers need to be modelled. An energy extended Computable General Equilibrium model (CGE), namely I3E, has been developed by Kelly de Bruin and Aykut Mert Yakut for this purpose.

A CGE model examines how inputs and outputs flow between production sectors of the economy and finally result in final goods consumed by households. Producers/consumers maximise their profits/utility given their budget constraints. This feature allows a CGE model to display behavioural change of different agents defined in the model.

The I3E model includes 39 commodities (or goods), 37 of which are domestically produced and imported, and two of which are not domestically produced but imported. These commodities include a set of carbon commodities including peat, coal, natural gas, crude oil, fuel oil, LPG, gasoline, diesel, kerosene, and other petroleum products. The production side of the model comprises 32 representative firms (or industries) that produce multiple products, where these firms are referred to as activities or sectors. Examples of industries are agriculture, textiles, chemical producers, construction. 27 out of 32 activities have endogenous investment decision via a dividend maximization problem. The model includes 10 household types distinguished by income level (5 rural and 5 urban) and 3 types of labour. The household level parameters are retrieved by using the Household Budget Survey (HBS), the Labour Force Survey (LFS), and the Survey on Income and Living Conditions (SILC). With its detailed structure, the I3E presents the opportunity to evaluate distributive effects within the economy, and therefore identify winners and losers at the household level.

I3E is a dynamic model, which incorporates economic growth driven by population and labour productivity growths. In the current version, the values of population growth and economic growth are retrieved from the medium-run estimates of the macroeconometric forecast model of the ESRI, namely COSMO (COre Structural MOdel for Ireland).

One of the main contributions of the I3E model in understanding the interaction of energy-economy-environment is the inclusion of the Emission Trading System (ETS). Each installation (mapped to the production activities defined in the model) covered by the ETS has freely allocated allowances, and the installation's emission exceeds its free allowance, the difference must be purchased in the EU carbon market. If the installation has a lower amount of emission than its allowance, the installation can sell the remaining allowances in the same market. The sequence of the freely allocated allowances is known for each installation until 2030 (the 3rd and 4th phases of the ETS). The I3E incorporates the sequence of allowances and endogenously calculates the cost of the ETS.

The year of 2014 is chosen as the base year to replicate the structure of the Irish economy. The I3E model's horizon is 2055.

The I3E model includes energy flows and emissions in addition to the standard monetary flows. Each production sector produces an economic commodity using labour, capital, material inputs, and energy inputs. The I3E model explicitly comprises a set of carbon commodities including peat, coal, natural gas, crude oil, fuel oil, LPG, gasoline, diesel, kerosene, and other petroleum products. Production activities produce in the cheapest way possible by using the optimal set of capital, labour, energy and other intermediate inputs based on both relative prices and substitution possibilities. When an energy policy is implemented (e.g. an increase in carbon tax) or in case of an external shock (e.g. an increase in international energy prices or ETS price), production sectors will where possible substitute energy inputs for other inputs and/or decrease the carbon content of their energy inputs by demanding cleaner energy.

Results

The explicit modelling of sectorial inter-linkages makes it possible to investigate the wider economic impacts of a specific shock or policy through the different transmission channels in the economy. For example, the economic implications of an energy tax in the transport sector can be evaluated both for the transport sector and other sectors through inter-sectoral spill-overs.

The I3E can be used to study the dynamic impacts of a carbon tax increase in terms of emission changes for both households and production sectors based on both the direct usage of the carbon commodities (e.g. electricity production) and the usage of carbon commodities in the production of other goods consumed (e.g. combustion). An increase in the carbon tax impacts the price of carbon commodities as well as other goods, wage per labour type and capital rent. These economy wide impacts can be considered and investigated. The I3E model does not have the tax and benefit system details of Bercholz and Roantree. Furthermore, it does not include the empirically estimated consumer responses to prices as Tovar Reanos and Lynch, but uses a nested consumption structure applying elasticities used in the literature. Tovar Reanos and Lynch also include more details in terms of household characteristics.

The current version of the I3E is amenable to run the impacts of different carbon tax revenue recycling schemes on activities, households, government, etc. Four different recycling schemes are evaluated: using the carbon tax revenue to reduce the public indebtedness (No Recycle Case); to reduce wage income tax rates (Wage Tax Case); to reduce the sales tax (VAT) rates of the non-energy commodities (Sales Tax Case); to recycle to households via the social welfare system (Transfer Case).

The following table summarizes the results of different recycling schemes on selected variables. In the table, the '-' sign indicates a decline in the value of a variable whereas the '+' sign indicates an increase in the value of a variable, relative to the business-as-usual (BaU) path. The number of signs shows the volume of the impact. The coloured cells show the best policy option for the respective variable.

	No Recycle	Sales Tax	Wage Tax	Transfer
Real GDP	- -	+ +	+	-
Consumer Price Index	+	+ + +	+ + + +	+ +
Debt-to-GDP	-	+ +	+ + + +	+
Real Disposable Income	- -	+	+ +	-
Private Consumption	- -	-	- - - -	- - -
Welfare	- -	-	- - - -	- - -
Emissions	- - - -	- -	-	- - -
Tax impact	regressive	progressive	progressive	regressive

GDP impacts range from a 0.5% decrease to a 1.2% increase in 2030 depending on the revenue recycling method. Real disposable income reduces more for poorer households (approx. 1%) than richer (approx. 0.5%). Similar to Bercholz and Roantree, and Tovar Reanos and Lynch, I3E finds that the carbon tax is regressive but can be made progressive through a recycling scheme. Urban households have higher impacts on real disposable incomes. But urban households experience higher levels of impacts in terms of equivalent variation, similar to Bercholz and Roantree, and Tovar Reanos and Lynch. EV increases by approx. 2.5% for the poorest rural household and 2% for the richest rural household. For urban households the increase for the poorest urban household is 1.3% and the richest is 1.5%. Price levels impacts will depend on the recycling scheme ranging from a 0.3% increase to a 9% increase. This shows the importance of considering secondary price impacts. Household emissions are reduced by around 10% in 2030 with a tax of 90 Euro per ton.
Looking at production sectors, value added decreases are highest in transport, electricity and mining. Value added increases in many other production sectors.

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They furthermore investigate the use of revenue recycling to reduce the repressiveness of the carbon tax increase. They examine a 'flat' lumpsum transfer, where carbon tax revenues are shared across households equally. Using revenue recycling redistributes income to poorer households making the first three quantiles better off and decreasing inequality. Moreover, they examine a 'targeted' transfer where carbon tax revenues are shared among household in an inverse proportion to their income, i.e. poorer households receive a higher transfer compared to richer. This further redistributes the income from richer to poorer households with where the first 2 quantiles are significantly better off with the carbon tax increase.

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One of the main contributions of the I3E model in understanding the interaction of energy-economy-environment is the inclusion of the Emission Trading System (ETS). Each installation (mapped to the production activities defined in the model) covered by the ETS has freely allocated allowances, and the installation's emission exceeds its free allowance, the difference must be purchased in the EU carbon market. If the installation has a lower amount of emission than its allowance, the installation can sell the remaining allowances in the same market. The sequence of the freely allocated allowances is known for each installation until 2030 (the 3rd and 4th phases of the ETS). The I3E incorporates the sequence of allowances and endogenously calculates the cost of the ETS.

The year of 2014 is chosen as the base year to replicate the structure of the Irish economy. The I3E model's horizon is 2055.

The I3E model includes energy flows and emissions in addition to the standard monetary flows. Each production sector produces an economic commodity using labour, capital, material inputs, and energy inputs. The I3E model explicitly comprises a set of carbon commodities including peat, coal, natural gas, crude oil, fuel oil, LPG, gasoline, diesel, kerosene, and other petroleum products. Production activities produce in the cheapest way possible by using the optimal set of capital, labour, energy and other intermediate inputs based on both relative prices and substitution possibilities. When an energy policy is implemented (e.g. an increase in carbon tax) or in case of an external shock (e.g. an increase in international energy prices or ETS price), production sectors will where possible substitute energy inputs for other inputs and/or decrease the carbon content of their energy inputs by demanding cleaner energy.

Results

The explicit modelling of sectorial inter-linkages makes it possible to investigate the wider economic impacts of a specific shock or policy through the different transmission channels in the economy. For example, the economic implications of an energy tax in the transport sector can be evaluated both for the transport sector and other sectors through inter-sectoral spill-overs.

The I3E can be used to study the dynamic impacts of a carbon tax increase in terms of emission changes for both households and production sectors based on both the direct usage of the carbon commodities (e.g. electricity production) and the usage of carbon commodities in the production of other goods consumed (e.g. combustion). An increase in the carbon tax impacts the price of carbon commodities as well as other goods, wage per labour type and capital rent. These economy wide impacts can be considered and investigated. The I3E model does not have the tax and benefit system details of Bercholz and Roantree. Furthermore, it does not include the empirically estimated consumer responses to prices as Tovar Reanos and Lynch, but uses a nested consumption structure applying elasticities used in the literature. Tovar Reanos and Lynch also include more details in terms of household characteristics.

The current version of the I3E is amenable to run the impacts of different carbon tax revenue recycling schemes on activities, households, government, etc. Four different recycling schemes are evaluated: using the carbon tax revenue to reduce the public indebtedness (No Recycle Case); to reduce wage income tax rates (Wage Tax Case); to reduce the sales tax (VAT) rates of the non-energy commodities (Sales Tax Case); to recycle to households via the social welfare system (Transfer Case).

The following table summarizes the results of different recycling schemes on selected variables. In the table, the '-' sign indicates a decline in the value of a variable whereas the '+' sign indicates an increase in the value of a variable, relative to the business-as-usual (BaU) path. The number of signs shows the volume of the impact. The coloured cells show the best policy option for the respective variable.

	No Recycle	Sales Tax	Wage Tax	Transfer
Real GDP	- -	+ +	+	-
Consumer Price Index	+	+ + +	+ + + +	+ +
Debt-to-GDP	-	+ +	+ + + +	+
Real Disposable Income	- -	+	+ +	-
Private Consumption	- -	-	- - - -	- - -
Welfare	- -	-	- - - -	- - -
Emissions	- - - -	- -	-	- - -
Tax impact	regressive	progressive	progressive	regressive

GDP impacts range from a 0.5% decrease to a 1.2% increase in 2030 depending on the revenue recycling method. Real disposable income reduces more for poorer households (approx. 1%) than richer (approx. 0.5%). Similar to Bercholz and Roantree, and Tovar Reanos and Lynch, I3E finds that the carbon tax is regressive but can be made progressive through a recycling scheme. Urban households have higher impacts on real disposable incomes. But urban households experience higher levels of impacts in terms of equivalent variation, similar to Bercholz and Roantree, and Tovar Reanos and Lynch. EV increases by approx. 2.5% for the poorest rural household and 2% for the richest rural household. For urban households the increase for the poorest urban household is 1.3% and the richest is 1.5%. Price levels impacts will depend on the recycling scheme ranging from a 0.3% increase to a 9% increase. This shows the importance of considering secondary price impacts. Household emissions are reduced by around 10% in 2030 with a tax of 90 Euro per ton.
Looking at production sectors, value added decreases are highest in transport, electricity and mining. Value added increases in many other production sectors.