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The macroeconomic principles and mechanics governing the impacts of broad carbon taxation on the UK economy

Policy Briefing 1: Carbon tax impacts on producer costs and competitiveness as the main determinant of macroeconomic outcomes

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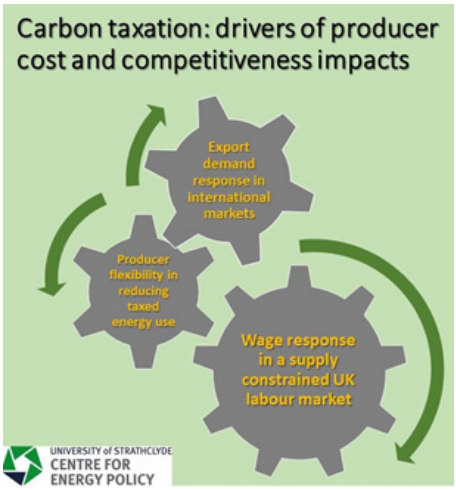
Summary

This is the first of two policy briefs being produced by the Centre for Energy Policy to help **build better policy understanding of what the macroeconomic impacts of introducing greater and broader carbon pricing/taxation may be.** We use multiple sector economy-wide computable general equilibrium (CGE) modelling to consider **the impacts of a hypothetical tax impacting the price of both domestically supplied and imported fossil fuels (gas and refined oil/petroleum) on a range of key macroeconomic indicators.** At this stage we run stripped down scenario simulations focussing solely on the introduction of the carbon tax, with the aim of isolating and explaining the mechanics of what impacts are likely to arise, and how they are affected by different assumptions.

The basic finding presented in this first briefing is that, **with no further policy intervention, decarbonisation action(s), or change in international trade conditions, the economy should be expected to contract with a sustained increase in the consumer price index (CPI) and losses in producer competitiveness where carbon costs are more fully internalised.** The main determinant of the extent of the contraction is what happens to the costs and competitiveness of UK producers.

The central drivers are: (1) producers' ability to reduce taxed energy use in their input mix, and (2) labour market conditions, particularly wage determination, in determining output prices, combined with (3) the extent to which export demand falls as UK producer prices rise. The second is particularly important. More specifically, **whether there is pushback in the labour market against reduced real wage rates as labour demand falls is crucial, not only in determining the extent of wider economy contraction, but also whether the introduction of a carbon tax will lead to a net public budget surplus.** The impact on the public budget is a central issue in moving forward to consider how any recycling of carbon tax revenues may affect outcomes. This will be considered in our second policy brief, where we present our main findings of our central scenario simulation analyses for the UK, including outcomes for households and potential distributional challenges arising.



> "....whether there is push-back in the labour market against reduced real wage rates as labour demand falls is crucial, not only in determining the extent of wider economy contraction, but also whether the introduction of a carbon tax will lead to a net public budget surplus."

1. Our scenarion simulation approach

Most existing analysis of the impacts of pricing carbon emissions rely primarily on micro-economic insights and analysis. Our research takes a more macro-economic perspective, using a multi-sector economy-wide computable general equilibrium (CGE) scenario simulation model. It focuses on identifying the main transmission mechanisms through which impacts on a range of key macroeconomic variables (quantities, prices, and government revenues) are driven and determined.[1]

The carbon tax is introduced via the output price of refined petroleum (oil) products and gas distribution. The tax rate on each is based on the average emissions generated when each of these fuel types is used, assuming a low-to-mid range carbon price of £50 per tonne of CO_2. The average emissions intensity in use of each of these broad fuel types is estimated using data from the 2018 release of the BEIS Digest of United Kingdom Energy Statistics (DUKES). The new (additional) £50 per tonne tax rate is introduced to the model at the rates of 45p and 16p per £1 respectively on the output prices of the UK 'Refined Petroleum Products' and 'Gas Distribution' sectors and on corresponding imports. It is passed on and paid by all users.

Note that, where we model the UK as a small open economy, there is no feedback effect on external fossil fuel prices, but, as the carbon tax impacts through UK markets and supply chains, there are additional upward pressures on UK fossil fuel prices. The greatest feedback effects are observed in 'Gas Distribution', which has relatively strong upstream supply chain linkages in the UK.

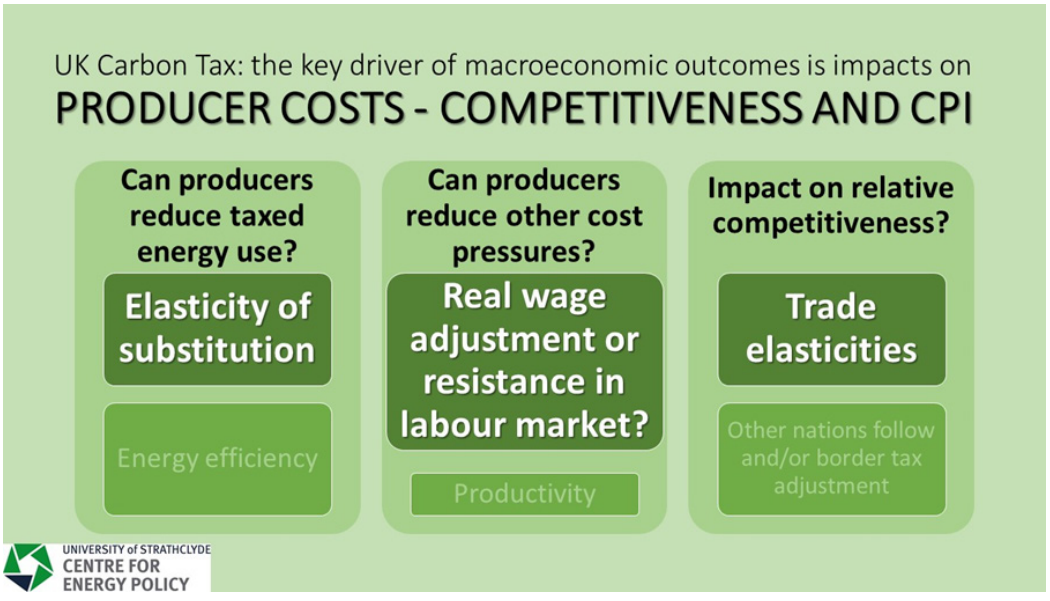
In this first policy briefing we focus on identifying the main determinants and drivers of outcomes solely from introducing the carbon tax.

We focus on long-run outcomes, where the economy has fully adjusted, a process that can take up to 30 years, but generally with 80%/90% of the simulated adjustment taking place within the first 10/15 years. We do not consider any recycling of revenues in this first briefing. That is, we initially assume that the UK government accumulates the revenue from the carbon tax in the public budget, where the net impact depends on two factors: (i) what happens to other tax revenues as the economy adjusts to a new long-run equilibrium; (ii) the impact of the CPI where government seeks to sustain levels of real spending. Issues around potential recycling of surpluses, and impacts on outcomes for UK households, are addressed in a second policy brief.

2. The three main mechanisms governing the macroeconomic impacts of a UK carbon tax

Figure 1 summarises how our analytical and CGE modelling work identifies the main determinant of outcomes at the macroeconomic level as being what happens to the costs and competitiveness of UK producers.

Figure 1:



The first two central drivers determine what happens to producer costs and, thus, prices:

(1) Producers' ability to reduce taxed energy use within their input mix in determining output prices. This will be affected by both (a) the ease with which fossil fuels can be substituted for cleaner energy and other production inputs in response to relative price changes using current technology, and (b) any technological change that allows the same output to be produced using less energy (energy efficiency). At this stage, our scenario simulation analyses focus on the former, (a).[2]

(2) Labour market conditions, particularly wage determination. We focus on the central issue of whether real wage demands will reduce as labour demand falls (unemployment rises), or whether there will be 'pushback'/resistance as workers attempt to protect their real take-home income as consumer prices rise. Going forward, it would be useful to investigate how increased labour productivity may impact outcomes.[3]

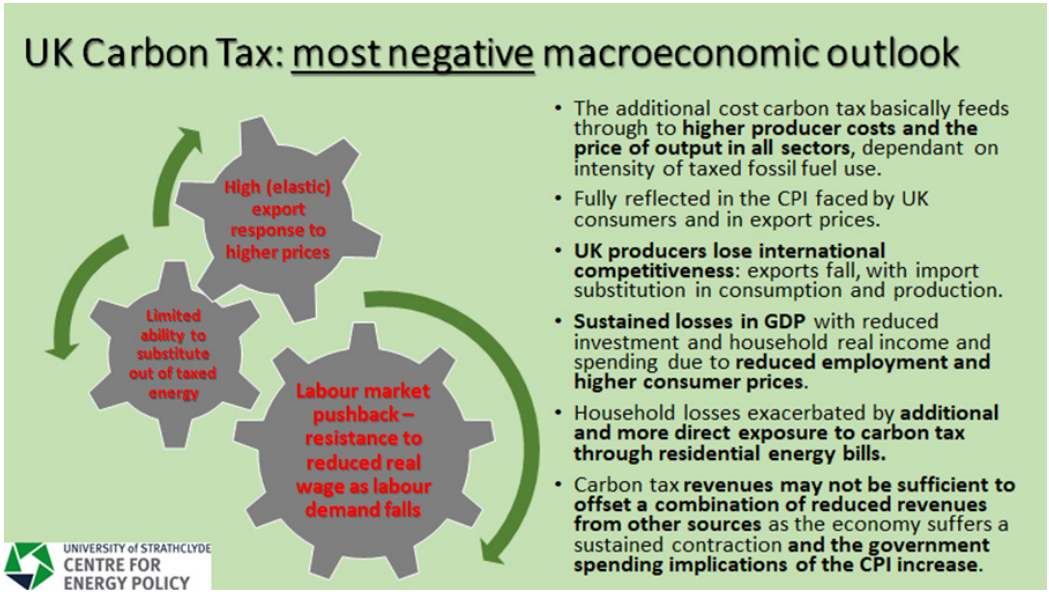
The third driver determines the relative international competitiveness impact where increased costs pass through to UK producer prices:

(3) The extent to which export demand falls as UK producer prices rise. Here we focus on the price elasticity of export demand. In future work it would be instructive to extend to consider how outcomes are affected if other nations are assumed to follow the UK in introducing an equivalent carbon tax and/or some border tax adjustment is made to offset relative international price effects.[4]

3. The 'worst case' scenario

Figure 2 summarises how a combination of minimal flexibility in productive energy use, labour market pushback, and price sensitive export demand will deliver the most negative macroeconomic picture following the introduction of a UK-wide carbon tax.

Figure 2:



In one scenario run we invoke potential 'worst case' assumptions for all three central drivers in Figure 1. This involves assuming: a relatively low inelastic value (0.3) on the ability of all UK producers to substitute away from taxed energy use (towards other inputs, starting with electricity); full pushback/real wage resistance in the labour market by imposing a fixed real (take-home) wage closure; a relatively high elasticity (2.0) on the price response of export demand for all UK producers.

Thus, when the tax is introduced, producers largely absorb the cost increase in the price of output, where the increase in the nominal wage rate faced by producers matches the 1.73% increase in the CPI. The crucial outcome is a substantial loss in the international competitiveness of UK producers.

Generally, rising UK prices trigger a 3.01% contraction in export demand but only a 0.60% fall in imports. The consequent reduction in activity in all UK production sectors contributes to a fall in total investment (-1.96%), GDP (-1.86%), employment (-1.75%) and total household spending (-1.27%), where households are also directly impacted by the carbon tax through their energy bills and running private vehicles.[5] Even with limited substitutability away from fossil fuels in production (and household consumption), there is a more than proportionate drop in (taxed) fossil fuel use of 11.57%. With gas use in UK electricity production driving a relatively high electricity price increase (5.77%), there is a wider reduction in the energy-intensity of the UK economy, with total energy use dropping by 7.85%.

Crucially, the contraction means that other (non-carbon tax) sources of government revenues decrease. In this worst case, the long-run outcome is an additional £0.41 billion of deficit accruing to the public budget, where £12.52billion gains in new revenue from the carbon tax are partly offset by £0.97billion losses in other tax revenues. However, revenue losses are in fact limited by the real wage resistance in the labour market: while total employment falls by 1.75%, the almost equal (1.73%) increase in the nominal wage rate limits the net impact on associated tax revenues. Rather, in this worst case, the negative impact on the public budget is driven by the corresponding increase in the CPI, where we assume government seeks to maintain pre-carbon tax real spending levels. This requires a £11.96billion increase in nominal spending.

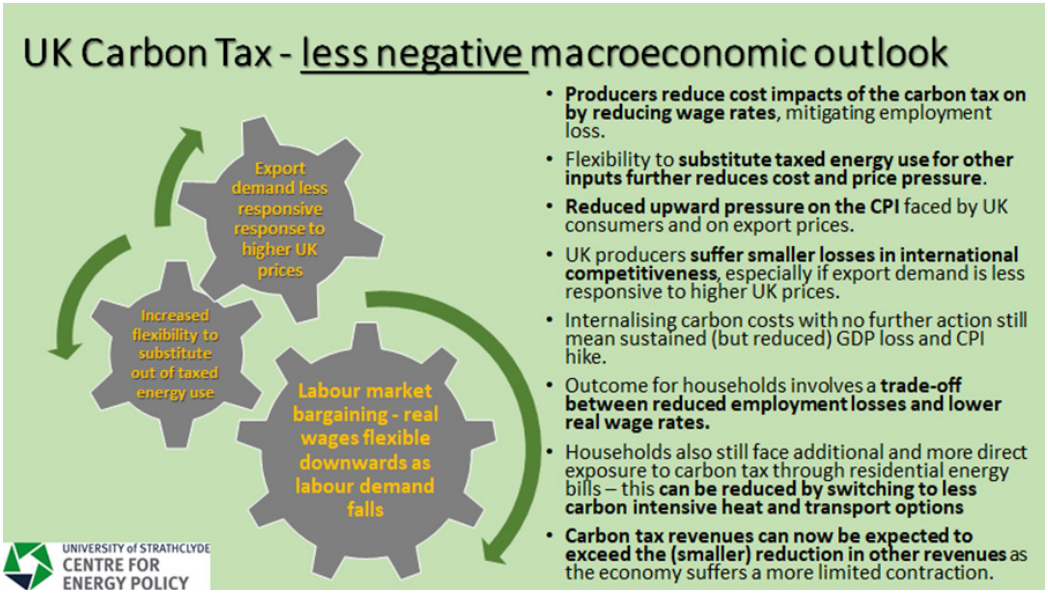
4. How the macroeconomic picture changes by varying assumptions about the key drivers

All our scenario results suggest that (with no other change or intervention) introduction of the new/additional carbon tax will trigger an economy-wide contraction, even where we change our assumptions regarding the drivers highlighted in Figure 1. This is to be expected because we are effectively introducing a new cost to the economy with no associated economic benefit. The question is the extent of the contraction, perhaps with the net impact on the public budget being a key metric to focus on, given that introduction of new taxation should not be expected to crowd out other revenue sources and/or government spending power.

Figure 3 summarises how more flexible conditions governing the three main drivers in Figure 1 are likely to deliver less negative macroeconomic picture following the introduction of a UK-wide carbon tax. The impacts of varying our assumptions about wage determination in the labour market prove to be the most important and are considered in the next section. However, the net public deficit outcome may be considered an extreme one, even where there is real wage resistance in the labour market.

We can examine this by running some 'low-medium-high' experimentation on our assumptions about UK producers' flexibility in reducing taxed energy use OR the export demand response to rising UK prices while retaining the labour market pushback assumption. First, if we increase the elasticity governing UK producers' ability to substitute away from taxed energy to a marginally elastic value of 1.2, a small net surplus of £2.30billion emerges. Second, if we decrease the export demand elasticity to only a marginally elastic value (1.1) the picture improves to one with a net surplus of £2.89billion. If we simultaneously adjust BOTH these elasticities, the outcome is substantially improved, delivering a net surplus of £5.61billion, associated with a much smaller (1.00%) contraction in UK GDP.

Figure 3:



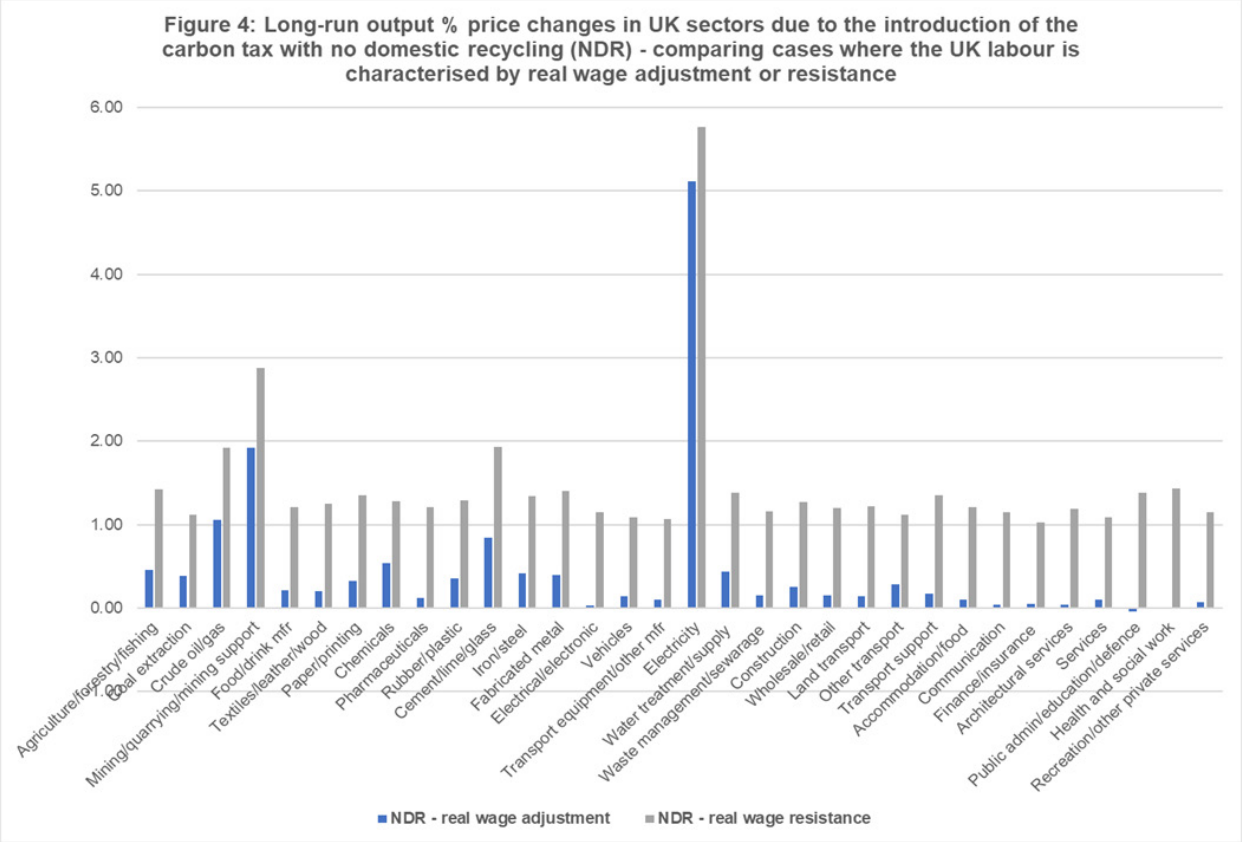
5. The importance of labour market conditions

On the other hand, our model universally (i.e., for any combination of substitution and export elasticities) delivers outcomes characterised by a net budget surplus if we change our assumption about labour market pushback to one where (through a national wage bargaining process) workers do not fully resist a decrease in their real wage as labour demand falls/unemployment rises.

Generally, the most appropriate 'central case' scenario for the UK labour market may be one where there is less resistance to falling real take-home wages (which does not necessarily mean nominal wage rates will fall), given evidence of sustained drops in real incomes in recent years. In the context of our carbon tax scenarios, this allows producers to mitigate overall cost and price pressures by reducing labour costs and reduce the extent of activity and employment loss.

If we change this one assumption (invoking a real wage bargaining closure on the UK labour market, where workers' real take-home wage demands are negatively related to the unemployment rate - but returning the export demand and producer substitution elasticities to their default values of 2.0 and 0.3 respectively) - and re-run our scenario simulation the macroeconomic picture changes markedly.

Figure 4:



Crucially, the gross and take-home real wage rate adjusts down by 1.18% (both gross and take-home/net of taxes on labour income). As shown in Figure 4, this has a marked impact on the extent of price increase required in all UK sectors (except fossil fuel supply, which is the vehicle for introducing the carbon tax). Price increases in core labour intensive service sectors are limited the most. Wage flexibility also reduces the extent of the sustained increase in the CPI (affecting domestic private and public spending) to 068%.

In terms of external demand and trade, the contraction in total export demand reduces by around two-thirds relative to the real wage resistance case in Section 3, to -1.07%, with now just a slightly larger (-1.05%) decrease in imports. The consequent reduction in activity in all UK production sectors contributes to a more limited drop, with total investment (-0.91%), GDP (-0.67%), employment (-0.47%) faring better than total household spending (-1.04%), where households, as the suppliers of labour, now bear a greater share of the (reduced) wider economy costs.

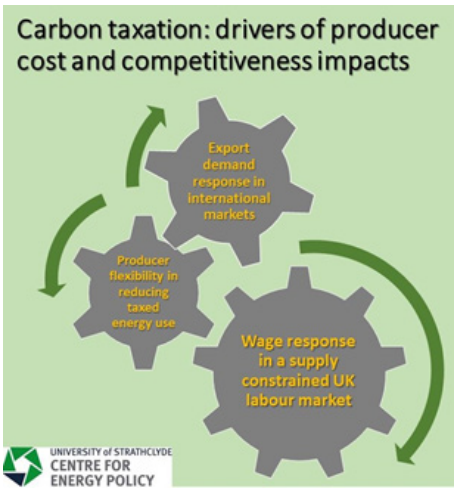
Crucially, just by changing the labour market assumption to one of real wage adjustment rather than resistance, the long-run outcome becomes one of £5.35billion of surplus annual revenues accruing to the public budget.

The gross carbon tax revenue gain (£12.60billion) is not much different to the real wage resistance case. However, there is an important change in how the revenue and spending impacts govern the public budget outcome. On the one hand, the reduced CPI pressure (+0.68% compared to 1.72%) means that additional nominal spending requirements on government in maintaining real pre-carbon tax spending levels are reduced (from £13.76billion to £3.12billion). On the other, losses in revenues from other sources grow to £4.94billion (from £0.71billion). The crucial point is that while the total employment loss is reduced (to -0.47%), the more than proportionate downward adjustment in the average real wage rate (-1.18%) erodes the income from employment generated and associated revenues to the public purse.

6. Central insight emerging to inform the next steps in the current briefing series

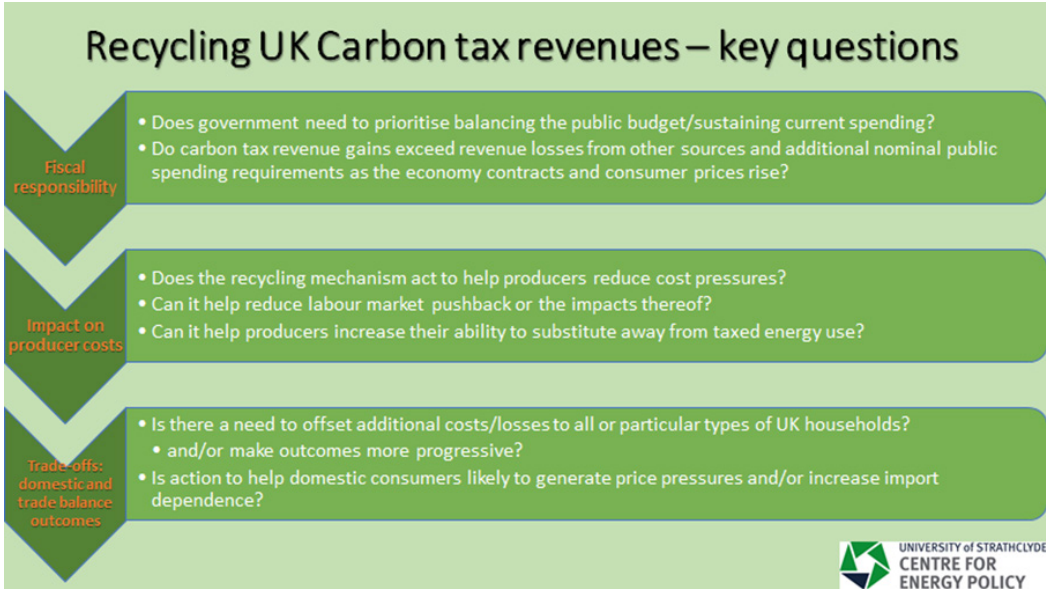
The central insight emerging from this first policy brief is the identification of the three main drivers of cost and competitiveness pressures on UK producers in determining the likely macroeconomic outcomes of introducing broader carbon taxation across the economy. These are summarised in Figure 5 and provide the foundations for our analysis going forward in the second policy brief on our initial research on macroeconomic principles and mechanics governing the impacts of broad carbon taxation on the UK economy. One potential focus for subsequent future research may be to consider whether outcomes improve further through the efficiency, productivity and/or international market factors identified in Figure 1 (alongside those analysed in Figures 2 and 3 and summarised in Figure 5).

Figure 5:



These are potential directions for future research at CEP. In this initial round of research, we will extend our analysis of the simulation results reported here in a second policy brief to focus attention on the key findings from our central scenario simulations, with particular focus on public budget and distributional outcomes. We will introduce focus on what is generally the second fundamental question addressed by carbon tax impact research: how might the use or recycling of revenues impact outcomes?

Figure 6:



We set this in a UK policy context by posing the first level of questions in Figure 6 in terms of national government's potential priorities on fiscal responsibility and sustaining current real spending commitments. On this basis, the scenario simulation work conducted to inform the second policy brief considers the impacts of recycling only net surplus revenues generated. This includes considering the implications if government must prioritise balancing the public budget where introduction of the carbon tax may generate a deficit (i.e., the possibility of 'negative recycling').

The final level of questions set out in Figure 6 also involves focussing a more detailed examination of outcomes for UK households in the context of understanding the wider picture and drivers of outcomes both with and without recycling. We will do this from a balanced budget recycling perspective, with focus on whether there is potential to alleviate costs on households, either directly or in the context of relieving pressure on the main drivers identified here: producer costs and competitiveness.

Contact

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Endnotes

1 A peer reviewed paper that underpins this work is available at https://doi.org/10.1016/j.eneco.2022.106393. This fully sets out the foundations, methodology, and results of the research reported here. However, the results in that paper are generated by an older version of our UK CGE model (calibrated using input-output tables published by ONS for the reporting year of 2016). All the results in this and the linked second policy brief are now updated to reflect outcomes generated when we rerun all scenarios with the model calibrated using the most recent input-output tables (for the reporting year of 2018). We have also updated the DUKES data used to inform the carbon tax rate from the 2018 to the 2020 release.

2 We note that previous work has shown that energy efficiency gains in production is likely to introduce stimulatory pressure to the economy. See papers by Allan et al., (2007) at https://doi.org/10.1016/j.eneco.2006.12.006, and Turner and Hanley (2011) at https://doi.org/10.1016/j.eneco.2010.12.002. Neither paper is open access but copies of both are available on request from karen.turner@strath.ac.uk.

3 We note that experimental simulations with our UK CGE model suggests that labour and/or capital productivity gains focussed in the delivery of low carbon energy supplies are likely to deliver both economic and environmental gains, reinforcing the findings of previous collaborative work focussing on a Spanish case study (see a paper by Sarasa and Turner, 2021, available open access at https://doi.org/10.1016/j.energy.2021.121335)

4 We have previously used our Scottish and UK CGE models to consider the impacts of unilateral actions involving increased carbon costs to producers in the context of carbon capture. See a paper by Turner et al. (2021), available open access at https://doi.org/10.1016/j.ecolecon.2021.106978, focussing on an applied case for Scotland. A paper extending the applied case to a wider UK setting, and exploring the implications of changes in the international context (other nations following and/or the introduction of a border tax adjustment) is published in the journal Climate Policy and is available (open access) at https://doi.org/10.1080/14693062.2022.2110031.

5 Our second policy brief will focus in more detail on household impacts, including distributional implications.