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Analysis

Who emits most? Associations between socio-economic factors and UK households' home energy, transport, indirect and total CO2 emissions

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ABSTRACT

Does the association between household characteristics and household CO_2 emissions differ for areas such as home energy, transport and indirect emissions? This question is policy relevant because distributional implications of mitigation policies may vary depending on the area of emissions that is targeted if specific types of households are likely to have higher emissions in some areas than in others. So far, this issue has not been examined in depth in the literature on household CO_2 emissions. Using a representative UK expenditure survey, this paper compares how household characteristics like income, household size, education, gender, worklessness and rural or urban location differ in their association with all three areas as well as total emissions. We find that these associations vary considerably across emission domains. In particular, whilst all types of emissions rise with income, low income, workless and elderly households are more likely to have high emissions from home energy than from other domains, suggesting that they may be less affected by carbon taxes on transport or total emissions. This demonstrates that fairness implications related to mitigation policies need to be examined for separate emission domains.

1. Introduction

Since households contribute substantially to the UK's total emissions – around 74% according to Baiocchi et al.'s (2010) estimate, including indirect emissions – a reduction of household emissions is essential for meeting the UK's carbon reduction targets. Additional climate change mitigation policies (in the following "mitigation policies") will thus be needed to reduce household emissions. To examine potential fairness implications of these policies, we need to analyse the distribution of emissions across household groups.

Two points are particularly relevant here: first, if factors other than income are associated with emissions, mitigation policies that put a price on emissions will have varying effects on different types of households independent of their income. Characteristics other than income thus need to be considered in distributional analysis of emissions. However, some characteristics such as income and education or income and rural/urban location are related to each other. Whilst bivariate analysis may find that each of these characteristics is associated with emissions, multivariate analysis is required to determine whether or not characteristics such as education or rural location remain associated with emissions after income is controlled for. So far, only few studies employ multivariate analysis to control for relationships between different factors, but examples are studies by Baiocchi et al. (2010), Gough et al. (2011) and DEFRA (2008) for the UK context and by Weber and Matthews (2008) and Lenzen et al. (2006) for other countries. However, these studies differ regarding the types of emissions studied and their conclusions on how various household characteristics relate to emissions.

Second, from a policy perspective it is relevant to examine whether the association between emissions and household characteristics varies for different types of emissions. For example, do emissions in different areas increase at the same rate with income or household size? Is rural location more important for transport or for home energy emissions? So far there is no study available that compares the role of household characteristics for different areas of CO_2 emissions whilst controlling for associations amongst these characteristics. But only such a comparison will reveal whether or not it might be possible to generalise claims regarding the (un-)fairness of mitigation policies, currently made for individual areas of emissions (e.g. Barnes, 2003; DEFRA, 2008; Dresner and Ekins, 2006; Grainger and Kolstad, 2010; Starkey, 2008).

To address this gap in the literature, this paper compares the role of household characteristics for home energy, transport, indirect and total household CO_2 emissions. Household characteristics include amongst others income, household size, age, worklessness, gender, education and rural/urban location. Whilst an analysis of distributional implications of mitigation policies goes beyond the scope of this paper, we will outline possible policy implications in Sections 5 and 6.

Our analysis is based on a representative expenditure survey in the UK, the Living Costs and Food Survey (LCF) and its predecessor

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the Expenditure and Food Survey (EFS), merged over the years 2006 to 2009. We combine expenditure data with other data sources to estimate household CO_2 emissions as discussed in Section 3. The analysis comprises two steps. First, unconditional associations between various household characteristics and different areas of CO_2 emissions are examined; second, conditional associations are analysed, applying multivariate OLS regression. This provides us with an indication of the types of households that might be particularly affected by mitigation policies targeting specific areas of emissions. Section 2 provides a more detailed overview of existing research in this area. Section 3 describes the data, data limitations and methods of analysis. Results are presented in Section 4 and discussed in Section 5. Section 6 concludes.

2. Previous Research

The extent to which socio-economic factors other than income and household size are associated with household CO_2 emissions and whether associations vary across emission domains remains contested in the literature. Whilst some authors have claimed that characteristics other than income and household size are not relevant for household emissions (e.g. Wier et al., 2001: 267), several multivariate studies found that characteristics such as employment status, education, rural/urban location, household composition and age remained to be associated with emissions once income and household size were controlled for (Baiocchi et al., 2010; DEFRA, 2008; Gough et al., 2011; Lenzen et al., 2006). Based on this evidence, we expect characteristics other than income and household size to be relevant for household emissions. However, the way in which these factors are associated with emissions and whether associations vary by emission domain is still an open question.

The role of income is widely discussed in the literature. All studies on this topic conclude that emissions in all different areas rise with income (e.g. Baiocchi et al., 2010; Brand and Boardman, 2008; DEFRA, 2008; Druckman and Jackson, 2008; Fahmy et al., 2011; Gough et al., 2011; Weber and Matthews, 2008). Several studies on non-UK countries also compare the distribution of CO_2 emissions or energy requirements over income groups for different domains (but without controlling for other factors). All of these studies find that home energy emissions are more regressively distributed than transport or total emissions (e.g. for the US or Spain Duarte et al., 2010: 181; Herendeen et al., 1981; O'Neill and Chen, 2002: 69). Only Gough et al.'s (2011: 50–3) study compares the role of income for different areas of greenhouse gas (GHG) emissions using multivariate analysis. Whilst income remains significant for each area of emissions, the coefficients are almost identical (Gough et al., 2011: Tables A2.3 and A2.7), suggesting that different levels of regressivity disappear once other factors are controlled for. This paper will examine whether this also holds in this study on CO_2 emissions.

Previous literature has also shown that household size and composition (e.g. the presence of children) are important factors for household emissions and that there are economies of scale once individuals share household resources (DEFRA, 2008: 5; Druckman and Jackson, 2008: 3184; Gough et al., 2011: 13–4). Using bivariate analysis, O'Neill and Chen (2002: 67–8) showed that per capita domestic energy requirements in the US drop much more with increasing household size than energy requirements related to transport. This indicates that economies of scale are larger for home energy than for transport emissions which would be highly relevant for the design of mitigation policies, particularly if they include per capita rebates or allowances. However, multivariate results regarding the presence of children are mixed so far: having a child was positively associated with direct CO_2 emissions in DEFRA's (2008: 82) study but negatively with total emissions in Baiocchi et al. (2010: 64). We thus hypothesise that household size has a larger 'effect' on transport than on home energy emissions in multivariate analysis and that the presence of children matters more for direct than for indirect and total emissions.

Findings regarding age also remain inconclusive: DEFRA's (2008: 82) study found that direct CO_2 emissions increased with age in multivariate analysis whilst Wier et al. (2001: 267) concluded from bivariate analysis that age had little effect on CO_2 emissions from home energy. Other bivariate studies showed that the relationship between age and transport emissions takes on an inverse u-shape (O'Neill and Chen, 2002: 65). Since older people may be less likely to travel and more likely to spend time at home, requiring energy for heating, we hypothesise that an inverse u-shaped relationship between age and transport emissions holds in multivariate analysis whilst the same may not apply for home energy emissions.

Several multivariate studies have included employment status: Gough et al. (2011) found unemployment to be negatively associated with GHG emissions in different areas, confirmed by DEFRA (2008: 82) for direct CO_2 emissions whilst Meier and Rehdanz (2010) found a positive relationship between unemployment and space heating expenditure. Since being out of work may increase the time spent at home, we expect emissions from home energy to be higher and emissions from transport to be lower for people out of work compared to those in employment.

Some studies have also included education in multivariate studies on emissions, again with differing results. Baiocchi et al. (2010: 61, 64) found that education and total emissions are positively correlated but that high education 'reduces' emissions once other factors are controlled for, supporting the hypothesis that awareness of environmental problems rises with high education and contributes to low carbon practices. However, Brand and Preston (2010: 16) found that those who attended university or full time education (which could be seen as a proxy for high education) had significantly higher transport emissions that those who did not. Lenzen et al. (2006: 192) found a negative association between emissions and high education for Australia but a positive association for Brazil and India, arguing that high education is a privilege of the rich in the latter and thus related to high emissions. Based on existing evidence for the UK, we expect education to be positively associated with transport emissions, but not with other types of emissions.

It is generally assumed that living in a rural location is associated with higher emissions due to greater car dependency and more isolated dwellings than in cities (e.g. DEFRA, 2008). However, since in the UK incomes in rural locations are, on average, significantly higher than those elsewhere,[1] the question arises whether rural location remains to be associated with emissions once income is controlled for and whether the association is stronger for transport or home energy emissions. Brand and Preston (2010) did not find location to be significant in OLS regressions on transport CO_2 emissions in the UK whilst DEFRA (2008: 82) found that those living in rural places had significantly higher direct (home energy and motor fuel) CO_2 emissions than those living elsewhere. This suggests that rural location is no longer associated with higher transport emissions once income is controlled for whilst the association with home energy emissions (which make up the largest share in the DEFRA study) may remain significant — an assumption we will test.

Neither Baiocchi et al. (2010), Gough et al. (2011), Lenzen et al. (2006), nor Weber and Matthews (2008) included gender in their multivariate analysis. DEFRA (2008) found that female headed households had higher direct CO_2 emissions than male headed households whilst Brand and Preston (2010) did not find a significant difference between men and women's transport CO_2 emissions. Since our study is based on household data we can only distinguish between 'female' and 'male headed' households, depending on the gender of

[1] Based on the LCF/EFS 2006–9, equivalised weekly household income was £367.0 in rural areas (standard error 6.1) and £331.6 (standard error 4.3) elsewhere which is significantly different at the 1% level.