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Emission inequality: comparing the roles of income and wealth in Belgium and the UK

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Highlights

- Wealth is positively correlated with emissions.
- Emission inequality according to wealth is higher than according to income.
- People with low income and low wealth face a cumulative disadvantage.
- Wealth inequality is a relevant dimension when designing climate policies.

Abstract

Many studies have investigated the distribution of greenhouse gas emissions associated with household consumption, highlighting that richer households have a substantially larger carbon footprint than poorer households. While these studies have typically used income or household expenditures as a proxy of households' living standards, the association between emissions and wealth has hardly been studied. Wealth is not just an important component of households' material living standards, known to be imperfectly correlated with income and expenditures, but it is also a very relevant dimension for climate policies. For instance, affluent households have more scope to invest in reducing emissions (e.g. insulation of their homes). Therefore, in this paper, we compare the inequality of emissions over wealth groups as well as groups defined by other living standard concepts such as income, expenditure and the joint distribution of income and wealth to add a focus on wealth to the analysis of emission inequality. Our study focuses on Belgium and the United Kingdom, which differ considerably in their level of wealth inequality. Our results highlight that the social distribution of emissions varies between expenditures, income, wealth and the joint distribution of income and wealth, with per capita emissions being more strongly associated with the joint distribution of income and wealth than with income alone. We also show that a significant share of households has both low income and low wealth, and may thus be lacking the means to prepare for a carbon-neutral future. Although increasing wealth taxation could provide much-needed revenues for low carbon investments, our results suggest that it would have a lower direct impact on the level of emissions and emission inequality compared to increasing taxes on high incomes.

1 Introduction

It is increasingly recognised that climate change and the transition to a decarbonised society are strongly intertwined with inequality issues (e.g. OECD Secretary General A. Gurría, 2019; European Commission, 2019). First, the impacts of climate change are very unequally distributed, with vulnerable groups being hit disproportionally by extreme weather events such as heat waves and flooding (Walker, 2012), and having less capacity to protect themselves against such events. Second, policies for decarbonising the economy (will) affect low- and high-income groups in different ways, with a high risk that distributive outcomes disadvantage vulnerable groups (Markkanen and Anger-Kraavi, 2019). Third, contributions to greenhouse gas (GHG) emissions are highly unequal, both between countries and between households and individuals (see e.g. Chancel, 2022; Ivanova and Wood, 2020). Multiple studies have investigated the household characteristics associated with GHG emissions in various countries, highlighting the social gradient of emissions (e.g. Gough et al., 2011; Büchs and Schnepf, 2013, Kerkhof et al., 2009; Ivanova and Wood, 2020; Lévay et al., 2021). Typically, emission inequalities have been evaluated from a perspective of household income or expenditures. However, another important dimension of socio-economic inequalities is wealth, which has only been linked to emissions in a small number of studies, such as Yang et al. (2017), Knight et al. (2017) and Apostel and O'Neill (2022). We contribute to the literature on carbon inequality by examining how emissions are distributed over wealth groups compared to income, expenditure or joint income and wealth groups.

There are at least four reasons why it is important to also consider the distribution of emissions in relation to wealth. First, living standards are not just determined by income or expenditures, but also by wealth. Wealth, including savings and assets, provides additional financial security when incomes decrease or unexpected costs arise, it creates independence and opens up a wider range of choices (Sherraden, 1991), it contributes to class status (Spilerman, 2000), and conveys economic and political power (see e.g. Winters and Page, 2009). As wealth is not perfectly correlated with income and expenditures,[1] and as it is more unequally distributed, distributive patterns of emissions might be different depending on whether income or wealth is used as the living standards concept. On the one hand, the wealthy have greater capacity for consumption and investment in carbon-increasing businesses and technologies, which exerts upward pressure on emissions. On the other hand, they also have greater resources to invest in carbon-saving technologies, which could reduce their carbon footprint. The second reason is that income and wealth inequality may be different channels that translate into carbon inequality, and ecological inequality in the broad sense. For instance, Yang et al. (2017, p. 247) state that "housing wealth inequality presents a different pattern from income inequality, which results in two correlated but different channels transferring social stratification into environmental inequality". The third reason is that the level of wealth inequality, even more so than income inequality, may impact on country level emissions through its negative effects on pro-environmental collective action and socially responsible behaviour. Knight et al. (2017) find that in high-income countries a 1 percent increase in wealth inequality is associated with a 0.795 percent increase in CO_2 emissions per capita. Their results also suggest that wealth inequality is more important in predicting emissions than income inequality. The authors relate their findings to political economy theories, which link economic inequality to environmental degradation via the unequal distribution of power (e.g. Boyce, 1994). The fourth reason is that wealth is at the nexus of social and climate policies: apart from reducing inequality, wealth taxes could generate revenue for climate policies, reduce emissions from luxury consumption, and have an indirect effect on society's commitment to reducing emissions via lower wealth inequality. However, Apostel and O'Neill (2022) point out that wealth taxes

[1] Expenditures refers here to consumption. Both terms are used as synonyms in this article.

could lead to higher emissions if they result in a search for higher-yielding investments by the rich. At the same time, to be effective and socially just, climate mitigation and adaptation policies targeted at households (e.g. insulation, use of electric cars), should take into account the distribution of wealth and its association with direct and indirect emissions by households. Hence, it is relevant to gain insight into the magnitude of emission elasticities with respect to wealth, especially in comparison to elasticities with respect to income and expenditures (for a discussion on income and expenditure elasticities we refer to Pottier (2022) and Lévay et al. (2023)).

This paper contributes to the literature on carbon inequality by examining the relationship between wealth and GHG emissions from a microlevel perspective, which has hitherto been done in only a handful of studies (including Yang et al., 2017; Apostel and O'Neill, 2022; and Chancel, 2022). In our analysis, we look into both the direct and indirect emissions emanating from household consumption. We pay particular attention to whether emissions are more or less unequally distributed over wealth groups compared to the living standard concepts of income, expenditure or joint income and wealth groups. We compare two countries: Belgium and the United Kingdom (UK). While both countries have a broadly similar level and distribution of GHG emissions per capita (Ivanova and Wood, 2020), the UK has a distinctly higher level of both income and wealth inequality than Belgium (Balestra and Tonkin, 2018). Therefore, the comparison of these countries is an interesting test case to gain more insight into how inequality in GHG emissions across the income distribution differs from inequality in GHG emissions across the wealth distribution. For this purpose, we combine two data sources for representative household samples of both countries: (1) emission data linked to household expenditure at the microlevel and (2) household wealth survey data, into which we impute the aforementioned emission data. This allows us to compare how GHG emissions are associated with living standard concepts such as income, expenditure and wealth. The analysis is conducted across various consumption categories.

The paper is organised as follows. Data and methods are described in Section 2. Section 3 presents theoretical assumptions about the relationship between wealth and emissions. In Section 4, we analyse the distribution of emissions over income, expenditures and wealth groups. In Section 5, we discuss the relevance of our results from a socio-ecological policy perspective, reflecting on some policy implications. The final section concludes.

2 Data and methods

Most international comparisons on GHG emissions (as e.g. in the Global Carbon Project (see. https://www.globalcarbonproject.org/) take a production perspective, i.e. emissions are counted where production takes place. However, as production and consumption have become increasingly geographically separated, a large share of emissions embedded in consumption can be attributed to a country different from where the goods are produced or services provided (Davis and Caldeira, 2010). Hence, an important complementary view takes a consumption perspective, i.e. emissions are counted where final goods and services are consumed, thus not only accounting for direct emissions in a country, but also for indirect emissions embedded in the goods and services consumed (see e.g. Chancel and Piketty, 2015). Such a consumption-based approach does not only provide an important complementary view on each country's contribution to global climate change, it also allows for a fine-grained distributive analysis within countries, as is done in this study.

There is no single survey which directly collects detailed information on income, expenditures, wealth, consumption-based GHG emissions, and other household characteristics for a representative sample of the population. Therefore, we combine expenditure surveys enriched with emission data with wealth surveys in Belgium and the UK. We first discuss the datasets that include household consumption and emission data, followed by a brief explanation of the household wealth surveys[2]. Thereafter, we explain the imputation of emissions data into the wealth surveys. Finally, we discuss various indicators of living standards, including those combining income and wealth, and discuss the univariate distribution of several key variables.

2.1 Data: combining household expenditure data with emissions

For **Belgium** we start from a database that contains a representative sample of households, called PEACH2AIR (Cooreman et al., 2019; Frère et al., 2018). The PEACH2AIR database is based on the Belgian Household Budget Survey (HBS), enriched with direct and indirect emissions related to the different consumption categories and assessed over a reference period of one year (2014). The 2014 HBS contains detailed information on socio-economic characteristics, consumption expenditures and household income for a nationally representative sample of 6135 Belgian private households (see for further details Lévay et al., 2021). Emission data related to household consumption have been estimated by the Federal Planning Bureau of Belgium (Frère et al., 2018) and have been integrated into the HBS by multiplying emission coefficients (that express tons of CO_2 equivalent emissions per euro spent on each product category) with expenditure data of different detailed consumption categories based on the Classification Of Individual COnsumption by Purpose (COICOP). Total household GHG emissions are the sum of a household's direct and indirect emissions. Direct emissions stem from the burning of fossil fuels by households (e.g. when driving a car or heating the home) and were computed using COPERT (a European road transport emission inventory model), and the Belgian national emissions inventory 2017 (fuels for domestic energy). Indirect emissions are embedded in the supply chain and waste management of the goods and services consumed by households, which were estimated on the basis of a single region input-output model developed specifically for the Belgian economy (see Cooreman et al., 2019 for more details).

For the **United Kingdom** we utilise the Living Costs and Food Survey (LCF) 2015/6 which has a sample size of 4912 households, combined with emission factors derived from environmental input-output analysis. The LCF is a representative, annual household level survey (DEFRA/ONS, 2020) that collects detailed information about household expenditure, also based on the COICOP classification as the HBS for Belgium, in addition to socio-economic characteristics of the household. Household emissions are estimated by matching household expenditure with emission factors per £ expenditure, derived from multi-regional input output (MRIO) analysis. Here, we utilise emission factors from the UK MRIO database developed by Owen and Barrett for the UK Government (DEFRA, 2021).

For both countries, once expenditure and emission factors are matched, broader categories of household emissions are created for energy, transport, food, and total emissions (which includes emissions from all other consumption). The analysis focuses on per capita emissions throughout (household emissions divided by household size). Given the differences in the modelling of GHG emissions, our focus is on the inequality of emissions rather than differences in the overall levels of emissions between Belgium and the UK, as the latter can be expected to be more affected by these methodological differences.

[2] We have chosen expenditure and wealth surveys in both countries that are as close as possible to one another in terms of time period. E.g. the wealth survey for Belgium refers to 2014/2015, while the one for the UK refers to 2014-2016, which almost entirely overlaps. The expenditure survey for Belgium refers to 2014, while the one for the UK refers to 2015/2016, which is the closest we could get. There are no reasons to expect a major bias on the results from this limited difference in time period.

2.2 Data: household wealth survey

For **Belgium** we make use of wave 2 of the Eurosystem Household Finance and Consumption Survey (HFCS) (data collection June 2014–January 2015). It includes detailed information on a sample of 2,238 households regarding their wealth, socio-demographics, gross incomes and consumption. The dataset contains interesting features, such as oversampling of the very wealthy to obtain a better coverage of the top of the wealth distribution (Eurosystem Household Finance and Consumption Network, 2016). We make use of the household weights provided with the data, which take account of over-sampling and non-response. Given that the HFCS includes only incomes gross of taxes and social insurance contributions, we use EUROMOD, the EU-wide tax-benefit microsimulation model (Sutherland and Figari, 2013), to derive disposable incomes taking into account all important details of the social security and tax system (see Kuypers et al., 2020).

For the **United Kingdom** we use wave 5 of the Wealth and Assets Survey (WAS) (data collection July 2014–June 2016). The WAS is a representative, longitudinal survey (ONS, 2022), collecting detailed information on assets, debt and income as well as socio-economic characteristics from households and their members in Great Britain. Like the HFCS, it oversamples wealthy households to achieve better coverage of the top income and wealth deciles. Household weights are provided to account for oversampling, as well as for response bias. Wave 5 has a sample size of 18,808 private households.

2.3 Imputing emission data in wealth surveys

We use a regression-based approach to impute consumption-based emissions into the household wealth survey data. For both Belgium and the UK, we first identify the socio-economic variables that are present in both the wealth and the expenditure datasets. Next, we run regressions in the expenditure datasets with household emissions as dependent variable and a range of explanatory variables that are also present in the wealth datasets (see Table A.2 in the Appendix). For both countries, the same types of variables are included, although the variable specification and the modelling varies, either because of data constraints, or because alternative specifications led to a better model fit. For both countries, we include variables related to disposable household income, household size, age of the reference person, tenure status, car ownership, and several characteristics of the dwelling. For Belgium, we also include variables for several broad expenditure categories (food, utilities and goods & services), which are not available in the UK WAS survey. For the UK we included more details on the characteristics of the reference person, such as their gender, ethnicity, education and employment status, as well as more detailed information on the tenure status and the number of rooms of the main residence (Table A.1. in the Appendix details the independent variables used for each country)[3]. We run separate regressions for total household emissions as well as for emissions related to food and drinks, domestic energy, and transport, for which sufficient information is available in all datasets (see Table A.2 in the Appendix for tables with the estimated coefficients)[4].

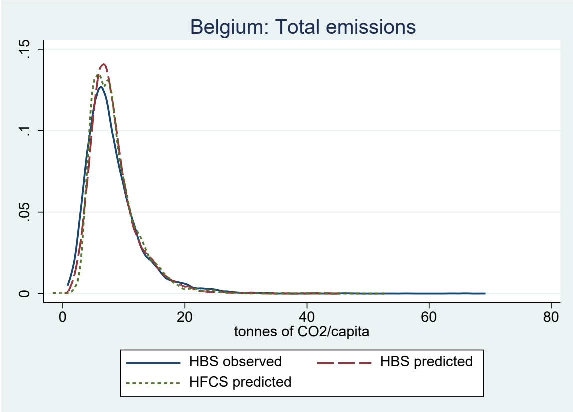
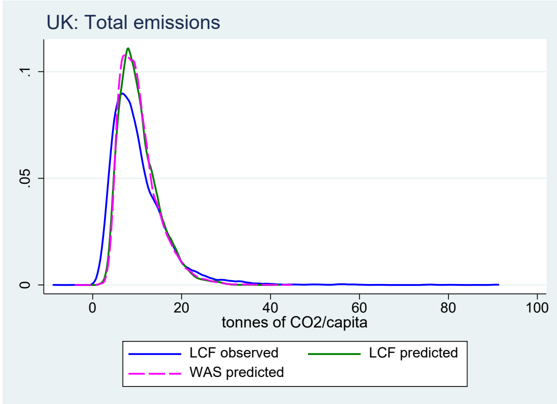
We then estimate emissions for each household in the wealth data. We do this by appending the expenditure and wealth datasets, running the regressions with the best fit on the expenditure survey and using the resulting coefficients to predict emissions for the observations in the wealth survey. The Kernel distributions in Figure 1 show how well the regression coefficients predict the observed total

[3] As a sensitivity analysis we have applied the UK imputation strategy to the Belgian data. While this clearly shows that the quality of the imputation is better when using expenditure variables in the imputation regression, the conclusions remain largely the same. Results of the sensitivity analysis are available from the authors upon request.

[4] All regressions are linear, with the exception of the transport emissions for which a log specification is used as it leads to a much better prediction.

emissions in the expenditure survey (used as a test of the goodness-of-fit) and how the predictions of the wealth survey compare to those (see Figure A.1. in the Appendix for the three subcategories of emissions). These graphs show that the predicted distribution of emissions in the wealth dataset aligns much more strongly with the observed distribution of emissions for total emissions as compared to emissions related to the three subcategories. Therefore, this paper focuses on total household emissions (additional results for the subcategories are presented in the Appendix and only briefly discussed in the main text; Table A.3 in the Appendix presents average emissions by income decile in the wealth surveys as compared to the expenditure surveys).

Figure 1. Kernel distributions of per capita GHG emissions

Belgium	United Kingdom
	

Source: Authors' calculations based on HBS and HFCS (Belgium) and LCF and WAS (UK) survey combined with consumption-related emission data. Weights are applied.

2.4 Concepts of living standards and inequality indicators

As primary measure of wealth we use the concept of net wealth, which is defined as the sum of financial assets (e.g. bank accounts, bonds, shares, etc.) and real assets (i.e. main residence, other real estate, vehicles, valuables and self-employment business wealth) less liabilities (e.g. mortgages, loans, credit card debt). This variable is readily available in the HFCS. For the WAS, we make some changes to the aggregate "total household wealth" variable used by the ONS (which includes net property wealth, net financial wealth, physical wealth and private pension wealth), namely by adding business wealth and subtracting wealth from household contents (see for instance Morelli et al., 2021 for a similar approach). As a sensitivity check for the net wealth variable, we also use gross wealth, i.e. before deduction of debts. The distinction between net and gross wealth is relevant because the inclusion of debt may skew the relationship between assets and emissions. In addition, we also show distributive outcomes for three different wealth components, namely liquid wealth, the main residence and other non-liquid wealth. Liquid assets are equal to the sum of bank accounts, bonds, shares, mutual funds and managed accounts. Since liquid assets are most easily converted into cash – and hence more important for consumption – and are much more unequally distributed than non-liquid wealth, the relationship with emissions might be different compared to other wealth categories. 'Other non-liquid assets' is a residual category including all other assets (i.e. mainly other real estate, self-employment business, cars, valuables, private pensions).

Finally, we also include a measure of living standards which considers both income and wealth. There are clear links between income and wealth, but because of saving and borrowing constraints the correlation is far from perfect (e.g. Jäntti et al., 2008). Hence, there are households who combine low income with high wealth and vice versa and this has implications for the measurement of poverty and inequality as well as the design and evaluation of socio-ecological policies (Kuypers and Marx, 2019; Kuypers et al., 2021). Therefore, it is argued that more prominence should be given to the joint distribution of income and wealth. One way to do this is to annuitize wealth and add it to income, as first proposed by Weisbrod and Hansen (1968) and summarized in equation (1):

$$AY_t = Y_t + \left[\frac{\rho}{1-(1+\rho)^{-n}}\right] NW_{t-1} \qquad (1)$$

$$n = T \; for \; singles, \qquad T_1 + (T - T_1)b \; for \; couples$$

where AY_t refers to annuitized income in year t, Y_t equals income received in year t, NW_{t-1} is net wealth held at the beginning of the year and ρ and n are the interest rate and length of the annuity. Here we apply a 2% interest rate which is most commonly used in the literature (e.g. Van den Bosch (1998); Gallusser and Krapf (2022)). The length of the annuity is expressed in terms of life expectancies by country, age and gender, where T_1 refers to time to death of the person who dies first, T time to death of the survivor and b is the reduction in the equivalence scale due to the death of the first person. Income (Y_t) should be interpreted as net of the yield from net wealth because this would be lost if net wealth is depleted (Weisbrod and Hansen, 1968, p.1317).

With the exception of Table 1, living standard concepts are equivalised using the OECD modified scale. While this is less straightforward for wealth compared to expenditures and income, the OECD (2013, p. 178) argues that when considering wealth as a resource supporting current consumption, as we do in this paper, it is appropriate to apply the same equivalence scale to wealth. Household weights provided in the wealth surveys are applied throughout the empirical analyses. The analyses for the expenditure concept are based on the household expenditures surveys (HBS and LCF), while for all other concepts the analyses are based on the wealth surveys HFCS and WAS.

Table 1 shows several inequality measures namely the Gini coefficient (which is 0 with perfect equality and 1 when one household holds all income/wealth/expenditures or emissions), the interdecile ratio D10/D1 (average per capita income/wealth/expenditure/emissions of households in the 10th decile divided by those in the bottom decile) and the share ratio ST10/SB50 (i.e. the share of income/wealth/expenditure/emissions of the top decile divided by the share of the bottom half). Unsurprisingly, the different inequality measures show that wealth inequality is the highest, while that of income, expenditure and emissions is much lower; joint income-wealth inequality is somewhere in between. Among the three different wealth categories, liquid assets and other non-liquid assets are considerably more unequally distributed than main residence wealth. In line with expectations, we find higher inequality in the UK than in Belgium for all inequality measures and living standards concepts. However, inequality in emissions in our data is higher in Belgium than in the UK. Following a brief consideration of hypotheses regarding the relationship between wealth and emissions, we analyse how emissions are distributed according to these different living standards concepts.

Table 1. Unconditional inequality of per capita emissions, living standard and wealth concepts

	Belgium			United Kingdom		
	Gini	**D10/ D1**	**ST10/SB50**	**Gini**	**D10/ D1**	**ST10/SB50**
Emissions	0.2813	6.43	0.72	0.2286	4.08	0.57
Expenditure	0.2172	4.85	0.57	0.3486	8.51	0.93
Income	0.2641	4.95	0.58	0.3455	8.29	0.93
Net wealth	0.6207	-211.10	4.31	0.6993	-585.23	9.23
Joint income-wealth	0.3742	9.64	1.10	0.4910	20.04	1.98
Gross wealth	0.5653	721.08	2.89	0.6981	4198.22	7.84
Liquid wealth	0.7950	8717.16	26.52	0.8554	32313.61	72.48
Main residence	0.5084	n/a	1.87	0.6151	n/a	4.82
Other non-liquid wealth	0.8204	16092	26.27	0.9123	650451.02	78.95

Notes: Gini=Gini coefficient; D10/D1=average of top decile (D10) over average of bottom decile (D1); ST10/SB50=share of top decile over share of bottom 50%.
Source: Authors' calculations based on HFCS (Belgium) and WAS (UK) survey combined with consumption-based emission data. Inequality in emissions and expenditures is based on the HBS (Belgium) and LCF (UK). The table displays per capita values, weights are applied.

3 Hypotheses: wealth and emissions

Based on existing literature, different hypotheses can be formulated regarding the impact of wealth on emissions and how it differs from the impact of income or expenditure on emissions.

1) Given that both income and expenditure are positively associated with household emissions (e.g. Büchs and Schnepf, 2013; Girod and de Haan, 2010; Gough et al., 2011; Isaksen and Narbel, 2017; Ivanova et al., 2017; Lenzen et al., 2006; Lévay et al., 2021; Steen-Olsen et al., 2016), wealth can be expected to be positively associated with emissions too as it provides additional purchasing power.

2) Since wealth tends to be more unequally distributed in society than income or expenditure (Piketty and Saez, 2014), one could expect emissions to rise more steeply across the wealth distribution.

3) However, in contrast to income, some types of wealth, e.g. property, land, fixed term investments, etc., are "non-liquid", meaning they cannot be used in the short term for new purchases. This could translate into lower emission inequality over the wealth distribution, especially for non-liquid types of wealth, compared to the income distribution.

4) Since wealth can be used for low carbon investments such as home insulation, domestic solar panels, heat pumps, electric cars etc., wealthy households might be able to reduce their emissions from some of the most carbon intensive consumption domains such as home energy or transport. This could reduce the inequality of the emission distribution over the wealth distribution. We will discuss these theoretical assumptions in light of our findings in section 5.

4 The distribution of emissions according to wealth and other living standard concepts in Belgium and the United Kingdom

We first analyse the distribution of GHG emissions in relation to four different concepts of living standards: equivalised disposable income, expenditure, wealth, and the joint distribution of income and wealth. Table 2 presents several measures of emission inequality, while Figure A.2 in the Appendix shows the distribution of emissions over deciles both for total and three subcategories of emissions. When we examine the distribution of emissions according to expenditure deciles, we find a steep social gradient, with per capita emissions ranging from 3.6 (bottom expenditure decile) to 14.7 tonnes CO_2e (top decile) for Belgium and from 4.9 to 21.5 tonnes CO_2e for the UK. Consequently, the decile ratio is highest for expenditures (4.04 in Belgium and 4.41 in the UK). As was found by earlier studies, emission inequality is substantially lower when measured against income, though it is still considerable. In both countries, inequality of home energy and food emissions over expenditure and income deciles is less pronounced than that of total emissions. Transport emissions are most unequally distributed over expenditure and income deciles in both countries (see Figure A.2 in the appendix). As seen above in Table 1, wealth is much more unequally distributed than income in both countries (especially in the UK). Results in Table 2 and Figure A.2 suggest that per capita emissions are also more unequally distributed over the wealth and joint income-wealth distribution compared to the income distribution (the exception are transport emissions in the UK). Interestingly, we find that the distribution of emissions according to the joint income-wealth concept is the most unequal one for both inequality measures in both countries. This is an indication of cumulative effects of income and wealth, as the social gradient is stronger when looking at the combined distribution of income and wealth as compared to both living standard concepts separately.

Table 2: Inequality of per capita emissions according to different concepts of living standards

	Belgium		**United Kingdom**	
	D10/D1	**ST10/SB50**	**D10/D1**	**ST10/SB50**
Expenditure	4.04	0.50	4.41	0.61
Income	1.41	0.24	2.48	0.39
Net wealth	1.85	0.33	2.50	0.41
Joint income-wealth	2.02	0.36	2.77	0.43
Gross wealth	1.87	0.32	2.37	0.37
Liquid wealth	1.67	0.30	2.25	0.37
Main residence wealth	n/a	0.32	n/a	0.35
Other non-liquid wealth	1.39	0.26	1.64	0.29

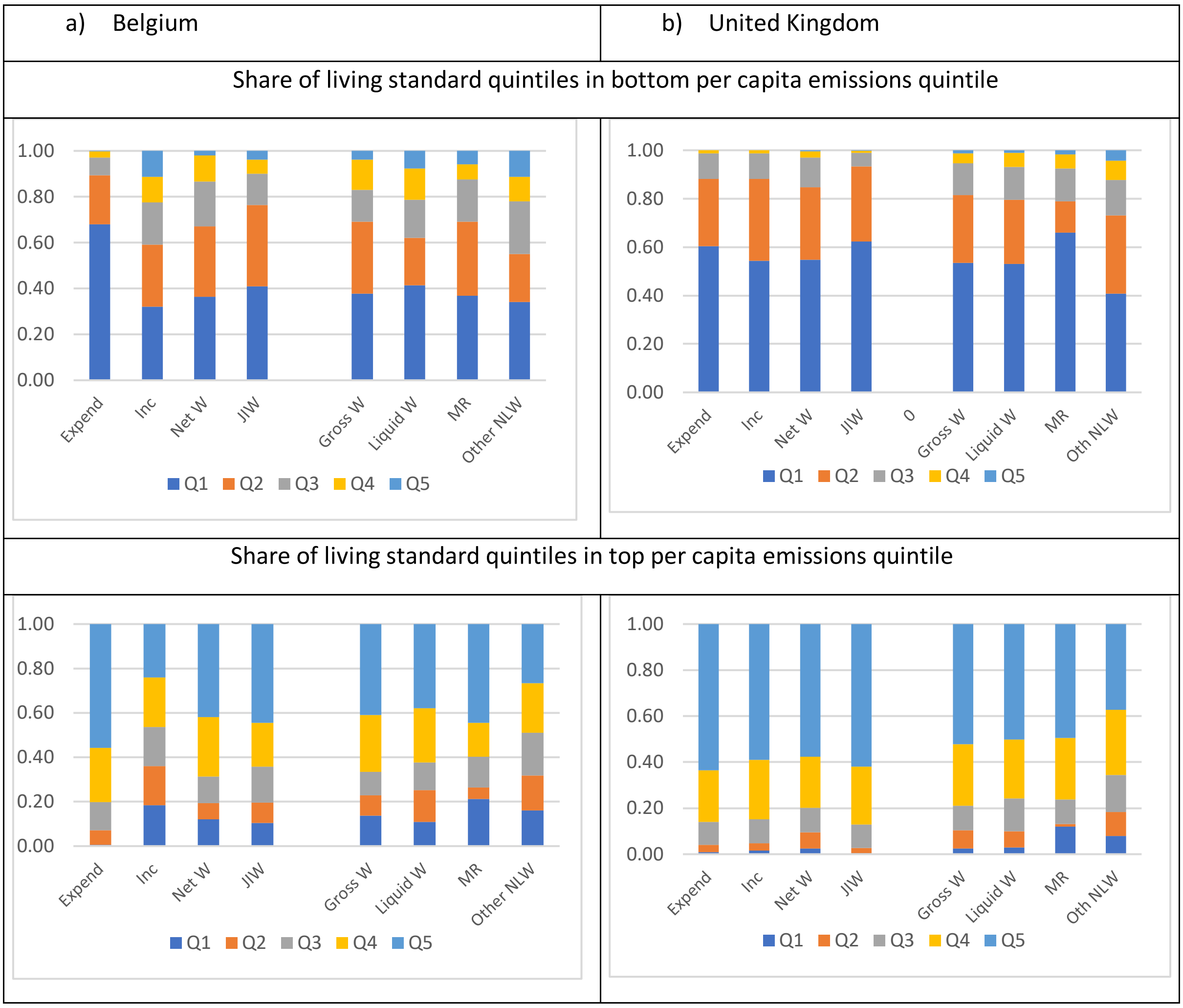
Notes: D10/D1 = average of top decile (D10) over average of bottom decile (D1); ST10/SB50=share of top decile over share of bottom 50%.
Source: Authors' calculations based on HFCS (Belgium) and WAS (UK) survey combined with consumption-related emission data. Inequality in expenditures is based on the HBS (Belgium) and LCF (UK).

When comparing emissions inequality between the two countries, clearly there is a larger gap in emissions across the distribution of living standards in the UK than in Belgium. Apparently, higher inequality in expenditures, income and wealth in the UK also translates into higher emission inequality over living standard distributions, in spite of lower inequality in the unconditional distribution of emissions in the UK. Interestingly, this does not apply across all consumption categories (Table A.4 in the Appendix): for food and energy & housing emissions, inequality is rather similar across both countries. For transport emissions, however, the pattern in the UK is much more unequal when considering inequality according to expenditures, income and the joint income-wealth distribution. This indicates that transport is more of a 'luxury' good in the UK compared to Belgium, perhaps due to relatively higher motor fuel and public transport prices and due to the higher incidence of air travel in the UK because of its larger surface area and island status.

We also compare emission inequality over the distribution of different wealth categories (Table 2; see also in the Appendix Figure A.3 and Table A.4). Total per capita emissions are most unequally distributed over net wealth. As hypothesised in section 3, total per capita emissions are more unequally distributed over liquid wealth than over non-liquid wealth in both countries. Per capita food and home energy emissions are also more equally distributed over non-liquid wealth than over the other wealth categories in both countries; in fact, households in the first two deciles of the 'other non-liquid wealth' distribution tend to have higher food and home energy emissions than those in the third decile. These findings confirm that non-liquid wealth may have less of an impact on consumption and related emissions than liquid wealth, especially for the consumption of necessities.

The top panel in Figure 2 (see also Appendix Figure A.4) presents the proportion of households according to different living standard quintiles in the bottom emission quintile, while the bottom panel presents the same for the top 20% emitters. In general, we find that the poor are overrepresented in the bottom emission quintile, while the rich are clearly overrepresented in the top emission quintile; this is more clearly the case in the UK than in Belgium, perhaps due to larger income and wealth inequalities and a higher correlation between these living standard measures and consumption expenditures in the UK compared to Belgium. Also, this pattern is more pronounced for the income distribution as compared to the wealth and the joint income-wealth distribution. Nevertheless, we find – in particular in Belgium — that there are poor households with high emissions and rich households with low emissions, which is an important consideration for designing policies for a just transition to a zero carbon economy. It is striking that in the UK almost none of the 40% richest belong to the 20% of households with the lowest emissions.

Figure 2. Share of households according to different living standard and wealth quintiles within bottom and top quintiles of per capita total emissions



Note: Expend=expenditures; Inc.=income; Net W=net wealth; JIW=joint income-wealth; MR=Main residence; Oth NLW=Other non-liquid wealth.
Source: Authors' calculations based on HFCS (Belgium) and WAS (UK) survey enriched with consumption-related emission data. The bars for expenditures are based on the HBS (Belgium) and LCF (UK).

Finally, we present elasticities of emissions for the different living standard and wealth concepts. Elasticities are a common way of summarizing the relationship between income (or expenditures) and emissions (see Pottier, 2022 for an overview). The income elasticity of the so-called household carbon footprint is a number that captures the percentage change in emissions when income 'increases' by 1 percent. Note that here, as in many papers on this topic, this should be interpreted as moving along the income distribution from low to high incomes (or expenditures or wealth) from a cross-sectional rather than a longitudinal perspective. Lévay et al. (2023) show that the choice of living standard concept, either income or expenditure, matters a lot when calculating such elasticities. We take their analysis further by comparing per capita carbon footprint elasticities for wealth concepts as well. Similar to Lévay et al.'s analysis, we present elasticities based on a bi-variate regression (or 'reduced form') and on a multi-variate regression ('extended'). In the latter, covariates related to household size, tenure status and type of housing are included as well as the age, education and activity status of the household reference person.

Results in Table 3 confirm that expenditure and emissions are much more closely linked than income and emissions: a bi-variate regression shows that a 1% increase in expenditure relates to an increase of 0.89% and 0.76% in emissions in Belgium and the UK respectively (0.87% and 0.67% in the extended regression model with covariates added), while a 1% increase in income is associated with an increase in emissions of only 0.39% and 0.50% in Belgium and the UK respectively (0.16% and 0.28% in the extended model). The close link between expenditure and emissions is not surprising given that emissions are estimated based on household expenditure. We also find that elasticities for wealth are much lower compared to income elasticities, where a 1% increase in net wealth is only associated with a 0.09% or 0.12% increase in emissions in a bivariate model in Belgium and the UK respectively (0.04% for both countries in the extended model). Elasticities for the joint income-wealth distribution are closer to the ones for income in both countries. The results for the different wealth concepts are highly similar, except for main residence wealth for which the elasticity is much higher than for the other wealth concepts. These findings are relevant from a policy perspective, as will be discussed in the next section.

Table 3: Elasticities for per capita total emissions and different living standard concepts.

Elasticity w.r.t.	Belgium		United Kingdom	
	Reduced	Extended	Reduced	Extended
Expenditure	0.89	0.87	0.76	0.67
Income	0.39	0.16	0.50	0.28
Net wealth	0.09	0.04	0.12	0.04
Joint income-wealth	0.40	0.18	0.39	0.25
Gross wealth	0.07	0.04	0.10	0.10
Liquid wealth	0.07	0.02	0.09	0.09
Main residence wealth	0.41	0.12	0.29	0.29
Other non-liquid wealth	0.06	0.02	0.10	0.10

Note: log-log specification, evaluated at the mean.
Source: Authors' calculations based on HFCS (Belgium) and WAS (UK) survey combined with consumption-related emission data. Expenditures perspective is based on the HBS (Belgium) and LCF (UK).

5 Discussion

It is well established that households with high expenditures or high incomes tend to have higher GHG emissions than those with lower incomes or expenditures. However, income and expenditures capture only a part of households' living standards and financial capacity to consume. Wealth is a very important other part: it does not only influence the capacity to consume high-emitting luxury goods and services, but also the capacity to invest in climate mitigation and adaptation at the household level, or, conversely, invest in the fossil fuel industry. In addition, wealth offers in many countries a largely untapped potential source for collecting additional revenue to invest in climate mitigation and adaptation policies and infrastructure. Finally, although income and wealth are to some degree correlated, there are important pockets of wealth-rich and income-poor households, as well as wealth-poor and income-rich households. Therefore, climate policies should take into consideration the distribution of GHG emissions over the wealth and the joint income and wealth distributions.

This paper is one of the first attempts to look further into this question. While some caution is required given that statistical matching was applied for the imputation of GHG emissions into a dataset of wealth and income, several findings stand out which seem sufficiently robust to inform further research and policy decisions.

First, we find that the social gradient of GHG emissions over the income and expenditure distribution is also present for the wealth and joint income-wealth distribution. In fact, wealth and joint income-wealth are more strongly associated with GHG emissions than disposable income. This applies in particular to net and liquid wealth (but less so for non-liquid wealth). These findings align with the hypothesis that the more unequal distribution of wealth compared to income does translate into higher emission inequality. By 2015, particularly in the UK, very few rich households seem to have used their wealth to drastically reduce their total GHG emissions. This means that wealth, especially very high net and financial wealth, should be considered as a factor for designing climate policies. Our results suggest that emission reductions of the wealthy can be very important when it comes to meeting national reduction targets.

Second, our finding that the wealth elasticity of GHG emissions is very low, especially when compared to the income or expenditure elasticity, is relevant if one considers a wealth tax to reduce emissions of the wealthy, a proposal investigated by Apostel and O'Neill (2022). They have shown that the direct ecological impact of a wealth tax for Belgium would be very limited. The low wealth elasticities that we find confirm their results, indicating the limits of a general wealth tax as a green transition policy measure, as the direct impact on emissions can be expected to be low. However, we think such a tax may still play an important role more indirectly, i.e. by using the revenues from such a tax to fund transition measures. Still, as Apostel and O'Neill (2022) point out, one needs to consider the possible opportunity cost of a wealth tax, in the sense that a carbon tax might be more efficient in reducing emissions while it may generate similar levels of revenues (depending on the exact tax design). However, carbon taxes on necessities such as domestic energy (and to a lesser extent motor fuels) tend to generate regressive distributional impacts, burdening low-income households more than high income households relative to income (e.g. Büchs et al., 2021), which calls for the consideration of a carbon fee and dividend approach (see e.g. Fremstad and Paul, 2019). However, such a scheme would require specific help for high-emitting households with low income and wealth, to transition to a consumption pattern with lower emissions. Otherwise they will be disproportionally hit by a carbon fee and dividend approach. In addition, such a scheme requires that low-income households are supported to access low-carbon housing and transport, as otherwise they will become net contributors of carbon tax and dividend schemes over time. In contrast, due to the very unequal distribution of wealth, wealth taxes tend to be progressive, putting the highest burdens on richer households (Saez and Zucman, 2019). Wealth taxes therefore tackle economic inequality, which is an important goal in and of itself. Furthermore, wealth taxes could be a more stable tax base in the long term, as carbon taxes should lead to a reduction of carbon (and hence tax base and tax revenue). In addition, Knight et al. (2017) found that in high-income countries a 1 percent increase in wealth inequality is associated with a 0.795 percent increase in CO_2 emissions per capita, Therefore, a reduction in wealth inequality in rich countries may also indirectly contribute to a better performance with respect to climate mitigation by boosting pro-environmental collective action and socially responsible behaviour.

Third, our results show that it is important not only to consider the income dimension when designing transition policies to a zero carbon society, but that the wealth dimension is relevant too. We have shown that the possible cumulative disadvantage of low income and low wealth cannot be neglected, especially for households with relatively high emissions. Households with high emissions and both high income and wealth could be targeted with taxes on high carbon luxury goods. In addition, these households are unlikely to face serious budgetary constraints when it comes to investing in low-carbon technologies. This may be very different for other combinations of income and wealth. For instance, for households with high income and low wealth, which is typically the case for young homeowners with a mortgage, one might consider a system of loans, such that they can spread their investment in low-carbon technology (e.g. for insulation) over a longer time. For households in the reverse position, i.e. low income and high wealth, which is more likely the case among certain pensioners, a different policy track is appropriate. For this group, liquidity is an important issue, and also the fact that deep house retrofitting to conserve energy may be considered as highly burdensome (e.g. also due to administrative burden). A more tailor-made approach might then be appropriate, e.g. in the form of loans that help to invest into insulation and low carbon home energy technologies (and increase the value of their property). The cost of such loans could be compensated by reduced domestic energy expenditures or increased gains when selling the property. The group that suffers the most are households on low income and low wealth. This group has least scope to invest in carbon-neutral technologies and risks being trapped in e.g. high energy-cost housing. For this group, socio-ecological measures that target both social and ecological aims are very important. Examples are the provision of social housing in low or zero emission buildings, installing collective heating infrastructures or supporting energy saving measures for the poor.

6 Conclusions

The two major societal challenges of social inequality and climate change are closely interrelated, which is apparent when considering the distribution of emissions. Until now, most studies have evaluated emission inequalities from an income and/or expenditure perspective. We argue that in addition to income (or expenditures) wealth is a very relevant dimension as affluent households have more scope to contribute to GHG emissions, as well as to invest in reducing their emissions. In addition, wealth is not perfectly correlated with income and consumption, and it tends to be more unequally distributed.

Combining household income, expenditure, wealth and emissions data for Belgium and the UK, we have integrated the wealth perspective into the analysis of the social distribution of GHG emissions. Our analysis has some limitations. First, the results are dependent on the quality of the imputation of GHG emissions in the wealth surveys used. While the kernel distributions show a reasonable fit for total emissions and some consumption categories, there is room for improvement, for instance, by capturing more detailed expenditure data in household wealth surveys (which are currently not available). Second, we use cross-sectional data, implying that our results are relevant mainly for the short term, and that other data are needed for a longer-term perspective that can also incorporate behavioural reactions with respect to for instance carbon-neutral investment decisions financed out of wealth.

We find that per capita emissions are more unequally distributed over the expenditure than the wealth or joint income-wealth distribution. However, we find greater emission inequality according to the wealth and the joint income-wealth distribution than the income distribution. This suggests that the more unequal distribution of wealth than income does translate into higher emission inequality over the wealth distribution. The fact that emissions are distributed differently according to income as compared to wealth is also related to the far-from-perfect correlation between income and wealth. Households with high income and low wealth (e.g. young homeowners with a mortgage) have a different potential to reduce emissions compared to those in the reverse situation (such as many elderly), or compared to those that face a cumulative disadvantage of low income and low wealth. It would be interesting to extend this analysis to other countries. In addition, our findings are important for policy making, especially when considering socio-ecological policies for those (high emission) households that lack both income and wealth to invest in carbon-neutral technologies. These policy routes merit further investigation.

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CRediT authorship contribution statement

Milena Büchs: Writing – review & editing, Writing – original draft, Visualization, Software, Formal analysis, Conceptualization. Tim Goedemé: Writing – review & editing, Conceptualization. Sarah Kuypers: Writing – review & editing, Writing – original draft, Software, Formal analysis. Gerlinde Verbist: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A: Supplementary data

Supplementary material is available here:

https://ars.els-cdn.com/content/image/1-s2.0-S0959652624022674-mmc1.docx

Data availability

The authors do not have permission to share data.

References

Apostel, A., and O'Neill, D.W. (2022). A one-off wealth tax for Belgium: Revenue potential, distributional impact, and environmental effects. Ecological Economics 196, 107385. doi:10.1016/j.ecolecon.2022.107385

Balestra, C., & Tonkin, R. (2018). Inequalities in household wealth across OECD countries. Evidence from the OECD wealth distribution database. OECD Statistics Working Paper 2018/01, OECD Publishing: Paris.

Boyce, J. (1994) "Inequality as a Cause of Environmental Degradation." Ecological Economics 11:169–78.

Büchs, M., Schnepf, S.V. (2013). Who emits most? Associations between socio-economic factors and UK households' home energy, transport, indirect and total CO_2 emissions. Ecological Economics 90, 114–123. https://doi.org/10.1016/j.ecolecon.2013.03.007

Büchs, M., Ivanova, D., & Schnepf, S. V. (2021). Fairness, effectiveness and needs satisfaction: new options for designing climate policies. Environmental Research Letters, 16(12), 124026.

Chancel L (2022) Global carbon inequality over 1990–2019. Nature Sustainability 5(11): 931-938.

Chancel, L. & Piketty T. (2015) Carbon and Inequality: From Kyoto to Paris. Paris, France: Paris School of Economics.

Cooreman, G., Frère, J.-M., Zsuzsa Lévay, P., Vanhille, J., Verbist, G., Goedemé, T. (2019) Analysis of the air pollution associated with household consumption in Belgium in 2014: the case of greenhouse gas emissions. Federaal Planbureau Working Paper 08-19

Davis, S.J., Caldeira, K. (2010) Consumption-based accounting of CO_2 emissions. Proc. Natl. Acad. Sci. U. S. A. 107, 5687–5692.

DEFRA / ONS (2020). Living Costs and Food Survey, 2015-2016. [data collection]. 3rd Edition, Department for Environment, Food and Rural Affairs, Office for National Statistics; UK Data Service. SN: 8210, DOI: 10.5255/UKDA-SN-8210-5.

DEFRA (2021). The UK's Carbon Footprint. https://www.gov.uk/government/statistics/uks-carbon-footprint, Department for Environment, Food and Rural Affairs.Downey, L. (2015) Inequality, Democracy, and the Environment. New York: New York University Press.

European Commission (2019) Employment and Social Developments 2019: Zooming in on the Social Impact of Climate Change. ESDE Annual Review 2019.

Eurosystem Household Finance and Consumption Network (HFCN). (2016). The Eurosystem Household Finance and Consumption Survey - Methodological report for the second wave. ECB Statistics Paper No 17.

Fremstad, A., & Paul, M. (2019). The impact of a carbon tax on inequality. Ecological Economics, 163, 88-97

Frère, J.-M., Vandille, G., Wolff, S. (2018) The PEACH2AIR database of air pollution associated with household consumption in Belgium in 2014. Federaal Planbureau Working Paper 03-18.

Gallusser D and Krapf M (2022) Joint Income-Wealth Inequality: Evidence from Lucerne Tax Data. Social Indicators Research 163(1): 251-295.

Girod, B., de Haan, P. (2010) More or better? A model for changes in household greenhouse gas emissions due to higher income. J. Ind. Ecol. 14, 31–49.

Gough, I., Abdallah, S., Johnson, V., Ryan-Collins, J., & Smith, C. (2011). The distribution of total greenhouse gas emissions by households in the UK, and some implications for social policy (CASE No. 152). CASE, Centre for Analysis of Social Exclusion. London

Isaksen, E.T., Narbel, P.A. (2017). A carbon footprint proportional to expenditure - A case for Norway? Ecol. Econ. 131, 152–165.

Ivanova, D., Wood R. (2020) The unequal distribution of household carbon footprints in Europe and its link to sustainability, Global Sustainability, 20(3)

Ivanova, D., Vita, G., Steen-Olsen, K., Stadler, K., Melo, P.C., Wood, R., Hertwich, E.G. (2017) Mapping the carbon footprint of EU regions. Environ. Res. Lett. 12.

Jäntti, M, Sierminska, E. & Smeeding, T (2008) The joint distribution of household income and wealth. Evidence from the Luxembourg Wealth Study. Paris: OECD Publishing.

Kerkhof, A.C., Benders, R.M.J., Moll, H.C. (2009). Determinants of variation in household CO_2 emissions between and within countries. Energy Policy 37, 1509–1517.

Knight, K., Schor, J.B., Jorgenson, A.K. (2017) Wealth Inequality and Carbon Emissions in High-income Countries, Social Currents, 4(5), 403-412

Kuypers, S. & Marx, I (2019) The Truly Vulnerable: Integrating Wealth into the Measurement of Poverty and Social Policy Effectiveness. Social Indicators Research 142, 131-147.

Kuypers , S., Figari, F. & Verbist, G. (2021) Redistribution in a joint income-wealth perspective. A cross-country analysis. Socio-Economic Review 19(3), 929-952

Kuypers, S., Boone, J., Derboven,J., Figari, F., Verbist, G. (2020), Enhancing Microsimulation Analysis of Wealth-Related Policies in EUROMOD, International Journal Microsimulation, 13(3), 5-26

Lenzen, M., Wier, M., Cohen, C., Hayami, H., Pachauri, S., Schaeffer, R. (2006) A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan. Energy 31, 181–207.

Lévay, P.S., Vanhille, J., Verbist G., Goedemé, T. (2021) The association between the carbon footprint and the socio-economic characteristics of Belgian households, Ecological Economics, vol. 186, doi.org/10.1016/j.ecolecon.2021.107065

Lévay, P.S., Verbist G., Goedemé, T. (2023) Income and expenditure elasticity of household carbon footprints. Some methodological considerations, Ecological Economics, vol. 212 doi.org/10.1016/j.ecolecon.2023.107893.

Markkanen, S. & Anger-Kraavi, A. (2019) Social impacts of climate change mitigation policies and their implications for inequality, Climate Policy, 19(7), 827-844

Morelli, S; Nolan, B; Palomino, J; Van Kerm, P. (2021) Inheritances, gifts and the accumulation of wealth for low-income households. Journal of European Social Policy, 31(5), 533-548

OECD (2013) OECD Framework for Statistics on the Distribution of Household Income, Consumption and Wealth, Paris: OECD Publishing.

OECD Secretary General A. Gurría (2019) Climate. Reclaiming our Common Future. Fourth OECD Biennial Lecture on Climate Change. 3 July 2019, Geneva

ONS (2022). Wealth and Assets Survey, Waves 1-5 and Rounds 5-7, 2006-2020 [data collection], Office for National Statistics; UK Data Service, 15th Edition, Accessed 29 March 2022. SN: 7215, DOI: 10.5255/UKDA-SN-7215-15.

Piketty, T., & Saez, E. (2014). Inequality in the long run. Science, 344(6186), 838-843.

Pottier, A. (2022). Expenditure elasticity and income elasticity of GHG emissions: A survey of literature on household carbon footprint. Ecological Economics, 192,

Saez, E., & Zucman, G. (2019). Progressive Wealth Taxation. Brookings Papers on Economic Activity, 2019, 437-533.

Sherraden, M. (1991). Assets and the poor. A new American welfare policy. Armonk, New York: M.E. Sharpe Inc.

Spilerman, S. (2000). Wealth and stratification processes. Annual Review of Sociology, 26(1), 497-524.

Steen-Olsen, K., Wood, R., Hertwich, E.G. (2016) The Carbon Footprint of Norwegian Household Consumption 1999-2012. J. Ind. Ecol. 20, 582–592.

Sutherland, H., & Figari, F. (2013). EUROMOD: the European Union tax-benefit microsimulation model. International Journal of Microsimulation, 6(1), 4-26

Van den Bosch, K. (1998). Poverty and Assets in Belgium. *Review of Income and Wealth.* 44(2), 215-228.

Walker, G. (2012). Environmental Justice: Concepts, Evidence and Politics. London: Routledge.

Weisbrod, B.A. & Hansen, W.L. (1968) An income-net worth approach to measuring economic welfare. American Economic Review 58(5), 1315-1329.

Winters, J., & Page, B. (2009). Oligarchy in the United States? *Perspectives on Politics, 7*(4), 731-751.

Yang, Z., Wu, S., & Cheung, H. Y. (2017). From income and housing wealth inequalities to emissions inequality: Carbon emissions of households in China. Journal of Housing and the Built Environment, 32(2), 231–252.