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Abstract

Carbon pricing is on the rise, as evidenced, for example, by the European Commission's proposal to extend the trade in carbon emissions to the building and transport sectors. An important feature of carbon pricing is that it generates revenues which can be rebated to households. Rebating the revenues from household sector carbon pricing on an equal-per-capita basis or recycling of revenues to those most affected economically can compensate inequitable impacts, which is expected to increase support for carbon mitigation. This paper addresses carbon pricing and the rebating of carbon pricing revenues from the perspective of their impacts on subjective well-being (SWB). Against the background of pertinent findings in well-being research the paper argues that the rebating of revenues from carbon pricing in the household sector may not be able to compensate the negative effects of carbon pricing on SWB. Referring to research on how energy affordability on the one hand and income on the other affect SWB, it is suggested that the net SWB effect of household sector carbon pricing and equal-per-capita rebating of revenues may be strictly negative. This is not only problematic *per se*, but all the more so because drops in SWB have been found to be strong predictors of populist voting, which poses a serious threat to carbon mitigation policy.

Keywords: carbon pricing; rebating; energy affordability; subjective well-being; populist voting
JEL codes: I31, Q41, Q54, Q58

1. Introduction

Carbon pricing arguably is economists' preferred instrument for greenhouse gas mitigation. It comprises both carbon taxation and carbon cap & trade (emissions trading). Similar to emissions pricing in general, carbon pricing has the property of static and dynamic efficiency. In comparison with the pricing of many other types of emissions, carbon pricing has low transaction costs because the amount emitted can be computed from the quantity and specific carbon content of the fuels whose burning leads to the release of carbon dioxide. Due to its advantages, carbon pricing is on the rise, as evidenced, for example, by the European Commission's proposal to extend carbon cap & trade to the building and transport sectors (European Commission 2021).

An important feature of carbon pricing is that it generates revenues which can be rebated to households. Rebating revenues to households on an equal-per-capita basis or recycling of revenues to those most affected economically can compensate inequitable impacts of rising energy costs and is expected to reduce resistance to carbon mitigation (e.g., Van den Bergh and Botzen 2024). A case study for Germany computed the financial incidence of a building and transport related carbon cap & trade (European Commission 2021), combined with equal per-capita rebating, and found a positive net revenue for a four-person household and a negative net revenue for a one-person household, with less wealthy households facing more positive/less negative net effects (Kalkul 2023). A survey in five countries, including the US, found support in all countries for implementing a high carbon tax if its revenues are redistributed back to citizens (Caratini et al. 2019), and an ex-post study found moderate impacts of rebates on public support of a carbon tax (Mildenberger et al. 2022).

This paper addresses carbon pricing and the rebating of carbon pricing revenues from the perspective of their impacts on subjective well-being (SWB) – a measure that has been suggested to be an important indicator of societal welfare and progress (Stiglitz et al. 2009) and adopted as a standard for policy evaluation in countries such as the UK (HM Treasury 2021). The paper draws on well-being studies that used data from the U.S., Europe and Australia (Boyd-Swan and Herbst 2012, Welsch and Biermannn 2017, Prakash et al. 2020) to show that an increase in income by a given amount compensates only for a small fraction of the well-being loss from an increase in energy costs by the same amount.

Against this background, the paper argues that the rebating of carbon pricing revenues in the household sector may not be able to compensate the negative effects of carbon pricing on SWB. Referring to research on how the price of heating fuels on the one hand and income on the other affect SWB (Welsch and Biermann 2017), it is suggested that the net SWB effect of carbon pricing in the household sector and the rebating of revenues will be strongly negative on average. Specifically, pricing the carbon content of heating fuels at 100 Euro per ton of CO_2 is estimated to reduce life satisfaction (the most prominent measure of SWB) at a magnitude comparable to important life events (such as widowhood) even if the revenues are completely rebated to households. This is not only problematic *per se*, but all the more so because drops in SWB have been found to be strong predictors of populist voting, which poses a serious threat to carbon mitigation policy.

The idea that the rebating of carbon pricing revenues can compensate inequitable impacts and/or attenuate resistance to carbon pricing is based on economists' – and perhaps even laypeople's – standard assumption that "a dollar is a dollar", so that energy costs and income are commensurable in terms of utility. This commensurability assumption can, however, be called into question on several accounts. First, rebating of revenues from carbon pricing implies that not only an individual or household in question receives a rebate, but also other individuals and households to whom the individual compares. As shown by a large literature in SWB research, the well-being effect of income depends not only on absolute income but also on income relative to that of others (Clark et al. 2008). This implies that the income of others bears a negative externality on the individual considered, and the negative externality can be so strong that the well-being effect of an increase in income is almost annulled by an equally sized increase in comparator income (Clark et al. 2018). Since, as will be argued below, the effects of carbon pricing are unlikely to also be attenuated by comparison effects, relative income effects may undermine the ability of the rebating of revenues to compensate people for the effects of carbon pricing.

Second, according to the theory and evidence of loss aversion, "the aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount" (Kahneman and Tversky 1979, p. 279). Consistent with this assertion, De Neve et al. (2018) found with respect to macroeconomic fluctuations that the impact on SWB of national income losses is significantly greater as compared to equivalent gains. Similar research has explored microeconomic effects on SWB of gains and losses in personal income and status (Boyce et al. 2013, Di Tella et al. 2010, Vendrik and Woltjer 2007). Loss aversion suggests that the loss associated with carbon pricing may not be compensated by rebating of the revenues.

Third, the assumption of commensurability of energy affordability and income is akin to the standard proposition in public economics that cash transfers are superior to in-kind transfers because cash allows consumers to chose what to consume (Atkinson and Stiglitz 1976), In contrast to this proposition, a growing literature found that people prefer in-kind transfers in certain circumstances. For instance, people were found to have a (stated or revealed) preference for in-kind transfers as a means for tackling self-control problems (Liscow and Pershing 2022) or as an insurance against price risk with respect to "subsistence consumption" of food or energy (Gadenne et al. 2021). In line with such insights, fear that subsistence consumption of energy may become unaffordable may contribute to strong well-being effects of energy price changes as compared to income changes.

While the literatures on well-being and economic behavior offer several reasons why SWB may respond negatively to energy price increases in spite of compensating cash transfers, political science research has found that low levels of SWB affect people's voting behavior. For instance, low levels of SWB were found to predict anti-incumbent voting at the 2012 election in the U.S. and Donald Trump's victory at the presidential election in 2016 (Ward et al. 2021), and general dissatisfaction with one's personal well-being – and not merely dissatisfaction with governments – was found to play a significant role in the rise of European populism (Nowakowski 2021, Lindholm et al. 2024).

The paper is organized as follows. Section 2 provides the conceptual and empirical background on the roles of energy affordability and income for SWB, focusing specifically on relative income effects. Section 3 discusses existing evidence on the comparative impacts of energy affordability and income on SWB and provides a tentative assessment of the well-being effects of household sector carbon pricing *cum* revenue rebating. Section 4 provides a summary and outlook.

2. Background: Energy Costs, (Relative) Income and Subjective Well-Being

2.1 Conceptual Framework

The well-being assessment of carbon pricing and revenue recycling relies on an important property of individuals' utility function: positional concerns, which translate into relative income effects. This subsection describes a conceptual framework for capturing this.

An individual's ordinal utility, *U*, is assumed to be a function of the consumption of energy, *E*, and a non-energy good, *C*. Using a Cobb-Douglas specification, the *direct utility function* takes the following form:

$$U = \alpha lnE + \beta lnC + \gamma \ln(\frac{C}{C^*}) = \alpha lnE + (\beta + \gamma)lnC - \gamma lnC^* = \alpha lnE + (1 - \alpha)lnC - \gamma lnC^*$$

In this formulation, α, β and γ are positive parameters. C^* denotes the non-energy consumption of the individual's comparison group. The expression after the first equality sign thus says that the utility of *C* depends on both absolute and relative (or comparative) consumption, where the latter reflects positional concerns (Clark et al. 2008). The formulation deliberately assumes that the individual's energy consumption is *not* subject to comparison effects. The assumption relies on the idea that household energy consumption – in particular energy consumption for heating – responds mainly to physical needs rather than positional concerns. In addition, energy consumption (of oil and gas) in the household is not directly observable outside the household and, hence, difficult to compare.

The expression after the second equality sign results from simple algebraic manipulation. It highlights the circumstance that comparator consumption bears a negative externality on the individual considered. The rightmost expression involves the additional assumption $\beta + \gamma = 1 - \alpha$, so that the utility function is linear homogeneous in *E* and *C*.

Choosing *C* as the numéraire good and letting *Y* denote income and *P* the price of energy, utility maximization with respect to *E* and *C* subject to the budget constraint $P \cdot E + C = Y$ yields the demand functions $E = \alpha \frac{Y}{P}$ and $C = (1 - \alpha)Y$. Moreover, denoting by Y^* the income of the comparison group and assuming the same parameters for their utility function, one gets the demand function $C^* = (1 - \alpha)Y^*$.

Inserting the demand functions for C, E and C^* into the direct utility function and collecting terms gives the *indirect utility function*

$$U = A - \alpha lnP + lnY - \gamma lnY^*, \quad (1)$$

where A is a composite parameter that includes the parameters α and γ.

The indirect utility function (1) is the tool for assessing the effects of carbon pricing and the rebating of revenues. Importantly, such rebating raises not only Y but also Y^*. According to (1), the effect on an individual's utility of a one-unit increase of the logarithm of own income *and* comparator income equals $1 - \gamma$. It can be interpreted as the effect of increasing Y and Y^* by the same percentage. If (initial) own income and comparator income are the same, an increase by the same percentage means that they increase by the same absolute amount, as implied by an equal-per-capita rebating of carbon revenues. In the general case, the effect on utility of an equal absolute increase of Y and Y^* by one unit is $1/Y - \gamma/Y^*$.

2.2 Empirical Implementation

Empirical well-being research uses measures of reported subjective well-being (SWB) elicited in large-scale surveys as proxies for the theoretical (unobserved) notion of utility. To accommodate the survey-specific numerical scale of the SWB data, the empirical analog to (1) is specified as follows:

$$SWB = \tilde{A} + a \cdot lnP + b \cdot lnY + c \cdot lnY^*, \quad (2)$$

where the parameter b is expected to be positive and a and c are expected to be negative. Due to the log-linear specification, the parameters give the effects of percentage changes in the explanatory variables (more specifically, a doubling). In line with the discussion in the preceding subsection, the crucial factor for assessing the effects of an equally-sized (percentage) change in own income and comparator income is the sum of the positive parameter b and the negative parameter c.

Versions of equation (2) (but without the price variable) have been estimated many times on data from a variety of countries. Particularly useful are longitudinal panel data, that is, data which track individuals over time. Panel data permit to control for individuals' unobserved fixed characteristics (such as traits and dispositions) by means of fixed-effect estimation. The latter technique permits to identify how SWB is related to person-specific changes (rather than between-person differences) in an explanatory variable of interest. Panel data sets are, however, available only for a small number of countries.

Clark et al. (2018) provide fixed-effects estimates of equation (2) on longitudinal data from Germany, Britain, and Australia. The SWB indicator is life satisfaction measured on a scale from 0 to 10. Individuals' comparator income, Y^*, is defined as the average income of people of the same sex in the same age group, region and year in question. The regressions control for the usual socio-demographic covariates of SWB (being partnered or not, being unemployed or not, health status, education level) and include time and regional dummies, but omit the energy price. Assuming that energy prices are uncorrelated with own and comparator income, estimates with respect to the latter variables are not biased by this omission.

Table 1 shows the estimation results. As seen in columns (1), (3) and (5), the coefficients on own income and comparator income have the expected sign and are highly significant. The negative effects of comparator income show up clearly, and the size of the comparison effect is remarkable. It is about as large as (or even larger than) the positive effect of own income. This means that all you care about is your income relative to that of your comparators; absolute income plays no role for life satisfaction.

Table 1: How life satisfaction (0-10) is affected by own income and comparator income

	Germany		Britain		Australia	
	(1)	(2)	(3)	(4)	(5)	(6)
Log own income	0.26*** (0.01)	0.08*** (0.01)	0.16*** (0.01)	0.04*** (0.01)	0.16*** (0.01)	0.06*** (0.01)
Log comparator income	-0.25*** (0.04)		-0.23*** (0.07)		-0.17*** (0.06)	

Panel-data fixed-effects regressions. The regressions include controls (being partnered, not being unemployed, health status, education level) and time and regional dummies. Log denotes the natural logarithm (ln). Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01, Source: Clark et al. (2018), Tables 2.2 and 2.3.

The conclusion is that an increase of an individual's income and that of her comparators by the same percentage has no effect on her life satisfaction. If people have the same (initial) income as their comparators ($Y = Y^*$), an equal percentage increase is equivalent to an equal absolute increase. Thus an equal absolute increase of income – as implied by equal-per-capita rebates of carbon pricing revenues – also has no effect on life satisfaction according to these results. For those with $Y > Y^*$, an equal absolute increase of own and comparator income will affect life satisfaction negatively, whereas the life satisfaction of those with $Y < Y^*$ will be affected positively.

The evidence of the joint effect of carbon pricing and the rebating of revenues, to be discussed in the next section, does not explicitly involve comparator income. Columns (2), (4) and (6) in Table 1 will help to put that evidence in perspective. These columns report the results of "short regressions" that omit comparator income. As seen, the coefficients on own income drop considerably as compared to the corresponding "long regressions" (1), (3) and (5), respectively, but they are positive and significantly different from zero.

To understand these "short regression" coefficients, the omitted variable bias (OVB) formula is helpful. Following Angrist and Pischke (2009), the OVB formula can be paraphrased as follows: "Short equals long plus the effect of omitted times the regression of omitted on included". To illustrate, the formula for Germany reads as follows: $0.08 = 0.26 - 0.25 \cdot \frac{cov(Y,Y^*)}{var(Y)}$, where 0.08 and 0.26 are the "short regression" and "long regression" coefficients, respectively, and -0.25 is the coefficient of the omitted variable. The OVB formula tells us that a significantly positive "short regression" coefficient on own income, which we will find in the next section, does not rule out the possibility of own income effects being almost annulled by comparison income effects. If $\frac{cov(Y,Y^*)}{var(Y)} < 1$ "short regression" coefficients will underestimate relative income effects.

3. Well-Being Effects of Energy Costs and Household Income

3.1 Direct Evidence: Heating Fuels

While the preceding section showed that relative income effects may more or less neutralize positive well-being effects of an equal-percentage increase in own and comparator income, this subsection provides a comparison of the effects of household energy prices and household income on subjective well-being. The discussion draws on Welsch and Biermann (2017), a paper that merged data on the life satisfaction of more than 100,000 individuals in 21 European countries from 2002 to 2011 with data on quarterly prices for households of light fuel oil (LFO) and natural gas to study the relationship between subjective well-being and the affordability of energy. In contrast to the specification in equation (2), the study included the variables of interest (energy prices and income) in levels rather than logarithms. This is an advantage in the context of rebating revenues from carbon pricing as it permits direct conclusions with respect to absolute changes of the energy bill (due to carbon pricing) and income (due to rebating). A disadvantage is that the regressions do not include comparator income. As was discussed at the end of the preceding section, the "short regression" coefficients resulting from this omission may capture relative income effects only incompletely.

Drawing on results from that paper, this subsection addresses the following question:

Will the well-being effect of a given increase in the household energy bill (for oil and gas) be compensated by an equally sized increase in income?

Table 2 presents estimation results of well-being regressions from Welsch and Biermann (2017) along with some background information, and the derived effects on life satisfaction of a hypothetical carbon price of 100 Euro per ton of CO_2. Lines (1) and (2) report the estimated effects on life satisfaction (0-10) of an increase of household light fuel oil and natural gas prices by one Euro/MWh and of an increase in annual household income by one Euro, respectively. Importantly, the effects of the energy price changes are to be interpreted as effects of the implied increase in the energy bill. Therefore, the estimated coefficients implicitly capture the quantity of energy consumed: The estimated effect of a price increase will be large if the quantity consumed is large and if it is inelastic. Available evidence suggests a very low (short-run) elasticity of household energy demand.[1]

Line (3) reports the average annual consumption per household (MWh) in the period considered (2002-2011) for Germany as a case study, and line (4) reports the specific CO_2 emission factors (tons/MWh) for light fuel oil (LFO) and natural gas.

The remainder of Table 2 considers the effects of a hypothetical carbon price of 100 Euro per ton of CO_2 using the information provided in lines (1) to (4). Line (5) shows the induced changes in the prices of oil and gas (Euro/MWh) under the assumption that the carbon price is passed on to households according to the fuels' specific carbon content, and line (6) shows the effects of these price changes on life satisfaction (using the coefficients from line (1)). Line (7) displays the resulting change in the annual household energy bill, on the assumption that the quantities shown in line (3) are unchanged. Line (8) shows the effect on life satisfaction of rebating the amounts shown in line (7) using the coefficients from line (2).

Lines (9) and (10) compare the effects of the induced increase in the energy bill (line (6)) with the effects of rebating that amount to households (line (8)). It is seen in line (9) that the rebate compensates only 2.24 percent (oil) and 2.75 percent (gas) of the dissatisfaction from the energy price increase.[2] The net effect on life satisfaction (0-10) of the carbon-price-cum-rebate is -0.1219 (oil) and -0.1174 (gas). Since the "average" household considered here consumes oil *and* gas, the total effect is the sum of the two, that is -0.2393.[3] This is a sizeable effect. To illustrate, it is almost one half of the difference between being widowed and being married (Welsch and Biermann 2017).

[1] Clements et al. (2020) considered a version of the Cobb-Douglas framework discussed in subsection 2.1 in which a portion of demand is "subsistence consumption", that is, consumption whose quantity is fixed. They found the proportion of fixed household energy consumption in total household energy consumption to be 86 percent, the largest proportion of all commodity groups considered (including food). Accordingly, the income elasticity (0.37) and the price elasticity (-0.19) of household energy consumption were also the lowest of all commodity groups.

[2] The results reported are based on the assumption that the quantities consumed are not affected by the carbon price. The revenues to be rebated would be smaller than assumed above if demand were assumed to be more elastic, as would be the effect of the rebate on life satisfaction. If anything, the assumption of inelastic demand reduces rather than increases the discrepancy between the energy cost effect and the effect of rebating.

[3] A "real" German household typically uses either oil or gas for heating, but the quantities used in the oil-consuming and the gas-consuming households, respectively, are proportionately larger, as are the effects of the respective price changes.

Table 2: How life satisfaction (0-10) is affected by household energy prices and household income

	Light Fuel Oil (LFO)	Natural Gas
Coefficients from life satisfaction regressions (Welsch and Biermann 2017)		
(1) Energy price (Euro/MWh)	-0.00468	-0.00601
(2) Annual household income (Euro)	0.000022	0.000024
Background information		
(3) Average annual consumption per household (Germany, 2002-2011)	4.753 MWh	6.889 MWh
(4) Specific CO_2 emissions	0.2665 tons/MWh	0.2008 tons/MWh
Scenario: carbon price = 100 Euro per ton		
(5) Increase in energy price induced by a 100-Euro/ton carbon price	26.65 Euro/MWh	20.08 Euro/MWh
(6) LS effect of price increase (= effect of induced increase of energy bill)	-0.1247 (-0.00468*26.65)	-0.1207 (-0.00601*20.08)
(7) Increase of annual household energy bill induced by a 100-Euro/ton price increase	126.67 Euro	138.21 Euro
(8) LS effect of increase in annual income equal to line (7)	0.00279 (0.0000220*126.67)	0.00332 (0.000024*138.21)
(9) Proportion of dissatisfaction compensated by rebate (line (8)/(6))	-0.0223	-0.0275
(10) Net LS effect (lines (6) + (8))	-0.1219	-0.1174

Note: In Welsch and Biermann (2017), the LFO price was measured in USD per 1000 liter, and the estimated coefficient on the LFO price (-0.000364) therefore refers to a 1-USD increase of the price per 1000 liter. Given the calorific value of 9.8 MWh/1000 liter, a 1-USD increase in the price per 1000 liter corresponds to an increase in the price per MWh by 0.102 USD. Accordingly, the effect on life satisfaction (LS) of a 1-USD increase of the price per MWh is -0.000364*9.8 = -0.00357. Multiplying by the average exchange rate (2002-2011) of 1.31 USD/Euro gives the LS effects of a 1-Euro/MWh increase in the energy prices, as reported above. The coefficients on household income differ between the samples that include LFO prices and gas prices, respectively. The original coefficient estimates in Welsch and Biermann (2017) refer to steps of 6000 Euro and amount to 0.132 (LFO sample) and 0.145 (gas sample). The coefficients reported above refer to a 1-Euro increase in household income. They were obtained by dividing the original coefficients by 6000. Average consumption per household was computed from total household consumption of LFO and gas, respectively (Umweltbundesamt, Entwicklung des Endenergieverbrauchs der privaten Haushalte) divided by the number of households in Germany. Average consumption per household refers to a virtual "average" household in Germany, not to real households which typically use either oil or gas for heating (or none of those), but not both.

The root cause of the large estimated discrepancy between the energy cost effect of carbon pricing and the cash transfer effect of rebating is the small estimated effect of increases in income. The small estimated effect of income is, however, consistent with the literature. For example, an official guideline for well-being appraisal issued by the Treasury of the UK (HM Treasury 2021) derives from the literature that one point on the 0-10 life satisfaction scale is worth 10,000 to 16,000 British Pounds of annual individual income. The estimates reported in line (2) of Table 2 imply a range between about 14,800 and 16,200 Pounds of annual individual income for one point of life satisfaction.[4] If the computations above used income effects more in line with the lower end of the range indicated by the UK Treasury, this would not significantly change the results obtained: The relative ability of rebating to compensate for carbon pricing would stay well below five percent. In addition, as discussed in subsection 2.2, income coefficients estimated in conventional life satisfaction equations (those that do not control for comparator income) are unlikely to capture the full extent of relative income effects that arise if everybody's income rises by the same amount.

3.2 Direct Evidence: Gasoline

Two papers have estimated the well-being effects of changes in the price of gasoline and computed the income equivalence of such changes, that is, the increase in income required to compensate for a given price change (Boyd-Swan and Herbst 2012, Prakash et al. 2020). In this subsection, the quantities of gasoline consumed will be used to estimate the change in a household's total gasoline costs implied by a given price change. This price-induced change in gasoline costs will then be compared to the compensating income change found in the respective studies. The resulting "compensation rates" will tell us by how many dollars income must increase to compensate the dissatisfaction from a price-induced increase of the gasoline cost by one dollar.

Boyd-Swan and Herbst (2012) used panel data from the U.S. (1985-2005) to estimate life satisfaction equations that included gasoline prices. They report that the effect on life satisfaction of a price change by one standard deviation (SD), which is US$0.20 per gallon, is equivalent to a change in monthly household income by US$260 (or 6.5 percent). Given the annual gasoline

[4] As explained in the note to Table 2, the estimates in line (2) are based on effects on life satisfaction of increases in annual household income by 6000 Euro, which amount to 0.132 to 0.145 points. Given an average household size of about 2 in the period of observation, this corresponds to an increase in individual income by 3000 Euro. The estimates imply that one point on the 0-10 life satisfaction scale corresponds to an increase in annual individual income by 22,727 Euro ((1/1.32)*3000) and 20,690 ((1/1.45)*3000). Given the average exchange rate of about 1.40 Euro/Pound in the period considered, this corresponds to a range of 14,778 to 16,234 British Pounds of annual individual income.

consumption per household, which is 1281.10 gallons, an increase of the gasoline price by US$0.20 per gallon increases an average household's gasoline cost by U$256.22 per year or US$21.35 per month (assuming that demand is inelastic).[5] Hence, to compensate for the life satisfaction effect of an increase in the monthly cost of gasoline by about US$21.4, an increase in monthly household income by US$260 is required, which is the 12-fold. Put differently, an increase in income by 1 US$ compensates only about 8.2 percent (21.4/260 = 0.0823) of an increase by 1 US$ of the cost of gasoline. For people living in sparsely populated areas (presumed to be more dependent on vehicle use), the monthly income equivalence of a price change by 0.20 US$ per gallon is US$395 (because for them the estimated life satisfaction effect of a price increase is larger than in the overall sample). This would suggest that a 1-$ increase in income compensates only 5.4 percent (21.4/395 = 0.0542) of a 1$ increase in the gasoline cost – neglecting that their gasoline consumption is likely to be higher than the average.

Prakash et al. (2020) used panel data from Australia (2001-2017) to estimate life satisfaction equations that included gasoline prices. They state that the effect on life satisfaction of a price change by one standard deviation (SD), which is AU$0.1547 per liter, is equivalent to a change in annual household income by AU$6455 (or 7.3 percent). Given the annual gasoline consumption per household, which is 1220.96 liter, an increase of the gasoline price by AU$0.1547 per liter increases an average household's gasoline cost by AU$188.88 (assuming that demand is inelastic).[6] Hence, to compensate for the life satisfaction effect of an increase in the annual cost of gasoline by about AU$189, an increase in annual household income by AU$6455 is required, which is the 34-fold. Put differently, an increase in income by 1 AU$ compensates only about 2.9 percent (189/6455 = 0.0293) of an increase by 1 AU$ of the cost of gasoline. This compensation rate is remarkably similar to the corresponding values for heating fuels found in the preceding subsection (2.24 percent for oil and 2.75 percent for gas).

To asses these results, it should be noted that the estimated compensation rates are based on attributing the respective countries' total gasoline consumption to private households. To the extent that only a fraction of total consumption is used by households, the price-induced changes

[5] Gasoline consumption per household was computed by dividing total annual consumption (135.156 billion gallons) by the number of households (105.5 millions).

[6] Gasoline consumption per household was computed by dividing total annual consumption (15.494 billion liters) by the number of households (12.69 millions). The latter was computed from the population size (26.01 million) divided by average household size (2.05) derived from Prakash ert al. (2020).

in household gasoline costs will be proportionally smaller, and so will be the estimated compensation rates. The compensation rates computed above are thus likely to overstate the compensation potential of income. It should also be noted that the larger compensation rate found for the U.S. is consistent with the circumstance that the comparison income effect is smaller in the U.S. compared to Australia, so that the marginal satisfaction from income is larger and less additional income is required to compensate for a price increase.[7]

3.3 Evidence from Fuel Poverty Studies

While the preceding section has discussed direct evidence of the incommensurability (in terms of life satisfaction) of energy cost changes and income changes, additional evidence comes from a study of so-called fuel poverty (Biermann 2016). Fuel poverty is said to prevail if a household's expenditures on fuels exceed certain threshold values, for example, fuel expenditure shares being two times larger than the mean or median fuel expenditure share, or absolute fuel expenditures being above *and* absolute income being below given threshold values (high-cost low-income criterion – HCLI).

From the point of view of standard economics, fuel poverty is not an issue in its own right, but should be regarded as an aspect of general poverty, that is, low income. Whether this assumption holds was tested by Biermann (2016). He used more than 330,000 observations for about 40,000 individuals from the German Socio-Economic Panel (1994-2013), a representative survey that includes data on life satisfaction, income, and expenditures on heating fuels.

A selection of results from his fixed-effects regressions (which control for region, time and people's socio-economic characteristics) are reproduced in Table 3. As seen in columns (1) and (2), people whose fuel expenditure share exceeds two times the median and those who satisfy the HCLI criterion are significantly less satisfied. Importantly, this holds while the level of income is controlled for. Even if – in addition to the level of income – income poverty (having less than 60 percent of the median income) is controlled for, fuel poverty has a significantly negative effect, as seen in columns (3) and (4). Overall, the level of income, whether living in

[7] Clark et al. (2018) find that the comparison income effect is smaller in the U.S. than in Australia. Accordingly, the cross-section regression coefficients of life satisfaction (0-10) on log income are 0.31 for the U.S. and 0.16 for Australia (Table 2.2).

income poverty, and whether living in fuel poverty have separate significant effects on life satisfaction.

Table 3: How life satisfaction (0-10) is affected by income poverty and fuel poverty

	(1)	(2)	(3)	(4)
Net monthly household income	0.0348***	0.0354***	0.0282***	0.0295***
Income poverty			-0.189***	-0.185***
2*Median Expenditure Share	-0.107***		-0.0769***	
HCLI Poverty		-0.148***		-0.0760***

Fixed-effects regressions (Germany, 1994-2013, N = 330,888). Regressions control for region, time and socio-economic characteristics. *p<0.1, **p<0.05, ***p<0.01. Source: Biermann (2016)

Similar findings were obtained using data from other countries. For example, Churchill et al. (2020) found several measures of fuel poverty to significantly negatively affect Australians' life satisfaction while controlling for absolute and relative income.

The results on income, income poverty, and fuel poverty provide further support for the idea that energy costs and income have qualitatively different effects on life satisfaction, so that higher energy costs cannot fully be compensated by higher income.

3.4 Implications for Populist Vote

Studying the impacts of carbon pricing on subjective well-being – in particular life satisfaction – is important given that such measures have been suggested as indicators of societal welfare and progress (Stiglitz et al. 2009) and adopted as a standard for policy evaluation (HM Treasury 2021). Assessments of carbon pricing (and other policy instruments) from the point of view of life satisfaction are, however, not only important *per se*, but even more so because climate policy's impacts on life satisfaction may have further consequences in terms of voting behavior. As political science research has found, low levels of SWB predicted anti-incumbent voting at the 2012 election in the US and Donald Trump's victory at the presidential election in 2016 (Ward et al. 2021). Herrin et al. (2018) examined the electoral shift towards Trump through aggregate SWB and showed that the change was the greatest in areas that experienced the lowest

SWB, as well as the greatest drop in SWB prior to elections. General dissatisfaction with one's personal well-being also played a significant role in the rise of European populism (Nowakowski 2021). In particular, analysis of representative survey data from 14 European counties showed that low life dissatisfaction was significantly linked to right-wing populist vote in 2012–2018 (Lindholm et al. 2024). Specifically, almost a third of the most dissatisfied quartile of voters voted for radical right-wing populist parties (27 percent) compared to only 16 percent among the most satisfied quartile of voters.

Given populist political entrepreneurs' stance on climate change, general dissatisfaction's effect on voting poses a threat to climate policy (in addition to the threat to the future of liberal democracy).

4. Discussion and Conclusion

4.1 Summary and Interpretation

In the debate on policy instruments for greenhouse gas mitigation, household sector carbon pricing *cum* rebating of revenues has recently played a prominent role. A special focus has been on rebating revenues on an equal-per-capita basis. Such an approach has been assumed to increase the public support for market-based policy instruments such as carbon pricing (Van den Bergh and Botzen 2024).

In the context of this debate, the preceding sections have considered the conceptual background and empirical evidence pertaining to the question whether rebating of revenues will compensate consumers for the dissatisfaction from household sector carbon pricing. An affirmative answer to this question seems to be an important precondition for an increase in public support to arise.

On the conceptual level, several considerations suggest skepticism with respect to the assumption of a strong compensating effect of revenue rebating. The main reason for this skepticism relies on the notion of comparison income effects, which suggests that the satisfaction people derive from their income depends not only on the absolute level of income, but also on their income relative to the income of others. Pertinent evidence suggests that in wealthy countries the well-being effect of income works to a large extent through the relative-income channel (Clark et al. 2018). With respect to the rebating of carbon pricing revenues, this suggests that the satisfaction arising from such rebates paid to everybody, in particular, rebates by an equal amount per capita, is small.

A closer look at the relative income effect shows that it is based on relative consumption considerations, or conspicuous consumption, and that those considerations do not apply to all commodities alike. For example, people derive status from the cars they drive relative to the cars of their neighbors – the "Joneses". By contrast, relative consumption effects are less likely to prevail with respect to commodities that satisfy basic physical needs. Consumption of heating fuels, such as oil and gas, is a case in point. In addition, consumption of heating fuels is hardly observable by others, which would be required for it to serve as a vehicle for conspicuous consumption.

Against this background, satisfaction parameters from a study on the affordability of heating fuels (Welsch and Biermann 2017), applied to fuel consumption data for Germany, were used to estimate the effects on life satisfaction of introducing a hypothetical carbon price of 100 Euro per ton of CO_2 on heating fuels and rebating the revenues on an equal-per-capita basis. The coefficient on income in the pertinent life satisfaction regressions is small, but of a similar magnitude as in related literature. Together with the coefficients on the prices of heating oil and natural gas – which capture the importance of energy affordability for well-being – the coefficient on income suggests that revenue rebating compensates only a small fraction of the dissatisfaction from carbon pricing. Accordingly, the net life satisfaction effect arising in the carbon-pricing-*cum*-rebate scenario considered is negative and of a sizeable magnitude – about -0.24 on the 0-10 scale. More aggressive carbon pricing than 100 Euro per ton of CO_2 will entail larger dissatisfaction.

While these findings should be regarded as tentative, they are supported by well-being studies from the U.S. and Australia (Boyd-Swan and Herbst 2012, Prakash et al. 2020). The wel-being effects of income and gasoline prices estimated in these papers suggest that an increase in income by a given amount compensates only for a small fraction – about 3 to 8 percent – of the well-being loss from an increase in energy costs by the same amount.

While a small well-being weight on income is consistent with income comparison effects, a large well-being weight on energy affordability relative to the weight on income is consistent with individuals showing a preference for in-kind transfers over cash transfers when essential goods are concerned (Gadenne et al. 2021). A large negative effect of rising energy costs relative to the positive effect of an increase in income is also consistent with loss aversion (Kahneman and Tversky 1979).

Negative net satisfaction arising from carbon pricing (in spite of rebating) is not only problematic from a social welfare point of view, but even more so in the light of evidence that general dissatisfaction with life spurs right-wing populist voting (Nowakowski 2021, Ward et al 2021, Lindholm et al. 2024). Increasing power of right-wing political entrepreneurs – in turn – is a serious threat to effective climate policy (among other threats it poses).

4.2 Outlook

In interpreting the findings described above, it should be noted that they refer to a notional "average" individual or household. Depending on circumstances – in particular the level of fuel consumption and non-linearity in the income-satisfaction relationship – heterogeneity analysis may reveal positive net satisfaction effects for some segments of the population. In addition, instead of equal-per-capita rebating, income-dependent progressive rebating schemes may be considered, which could yield positive net effects at the bottom of the income distribution. Investigating such issues provides avenues for future research.

A final point to be emphasized is that the potentially problematic aspects of carbon pricing described here refer to carbon pricing in the household sector. They should not be construed as entailing skepticism with respect to carbon pricing in the commercial sector. With respect to the household sector, however, an issue of great academic and practical importance is the comparative assessment of carbon pricing and other climate policy instruments from the point of view of life satisfaction. For example, subsidizing the adoption of climate friendly technologies (such as home insulation, heat pumps or electric vehicles) – even if funded through higher income taxes – may be expected to have different, potentially more favorable net effects on life satisfaction. First, receiving payments earmarked for the adoption of climate friendly technologies is less likely to be subject to comparison effects than are cash transfers. Second, if comparison effects exist – because the relevant technologies (for example, electric vehicles) serve as devices for conspicuous consumption – it is precisely those comparison effects that may speed up the diffusion of the technologies in question. On the other side of the coin – the funding of technology adoption subsidies through higher taxes – the relative income effect may imply that the dissatisfaction from higher taxes – to be paid by everybody – will be small.

An appropriate design of household carbon pricing and rebating schemes and a comparative assessment of several climate policy instruments from a life satisfaction point of view await an in-depth analysis.

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