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Carbon Pricing and Revenue Recycling: An Overview of Vertical and Horizontal Equity Effects for Germany*

The European Green Deal and the proposed Fit for 55 package requires a tremendous and rapid reduction of greenhouse gas emissions to achieve climate neutrality by 2050. With the introduction of a second European carbon pricing scheme for the building and transport sectors, carbon pricing is supposed to become the cornerstone of European climate policy. Since ambitious emissions targets require a high carbon price—probably over 100 euros per ton by 2030—a socially balanced reform package is needed to avoid financial hardship for vulnerable and low-income households.

Socially unbalanced impacts from carbon pricing may arise as follows: first, carbon pricing puts in most high-income countries a larger burden on low-income households compared to their high-income counterparts as energy and many energy-intensive goods constitute basic goods. Without any compensatory measures, carbon pricing therefore tends to increase the spread across income groups and the overall societal inequality in real incomes (e.g., Fullerton 2011; Grainger and Kolstad 2011; Klenert et. al. 2018). Carbon-price impacts across different income levels represent the "vertical" dimension of inequality. Second, carbon pricing places a larger burden on CO_2-intensive households, independent of their position in the income distribution. Differences in CO_2 intensity—after controlling for income—represent the "horizontal" dimension of inequality. While increasing horizontal inequality may not increase overall inequality in real incomes, it is a politically–economically relevant dimension because of the individual loss-aversion eventually resulting in public resistance (Fischer and Pizer 2018). Figure 1 illustrates the income (vertical) and CO_2-intensity (horizontal) dimensions relevant for carbon pricing. Addressing both these dimensions paves the way for socially balanced climate policies.

To achieve a socially balanced climate policy, carbon-price revenues can be used to redistribute the carbon-price burden away from low-income and carbon-intensive households. This article assesses the vertical and horizontal inequality effects of various compensation schemes that partly use channels of existing transfer and tax policies. We illustrate these measures for the carbon price on transport and heating fuels introduced in Germany in 2021, looking at the direct incidence of increased gasoline, diesel, heating oil, and natural gas prices on German households. So far, a carbon price of 30 euros per ton CO_2 is planned for the year 2022, but calls for higher prices also already exist. We show which compensation measures actually provide relief to disadvantaged households and which do not. In assessing the performance of carbon pricing and relief measures as discussed or planned in Germany, this article also provides potential lessons for other high-income countries.

We find that equal-per-capita payments outperform all other considered compensation measures in terms of relieving low-income households. There is,

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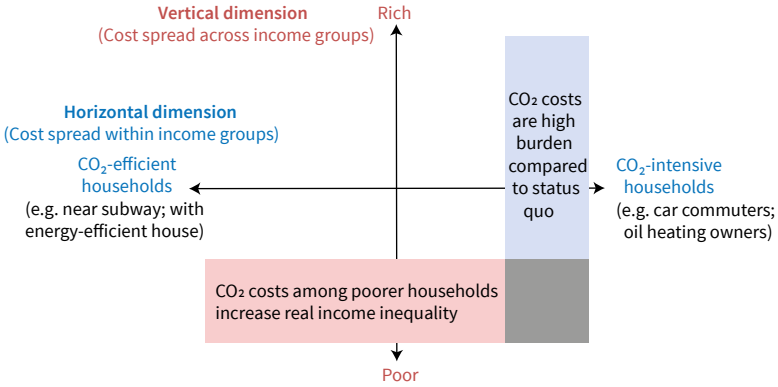
however, a trade-off between horizontal (CO_2-intensity) and vertical (income) inequality reduction. Pure per-capita payments make low-income households better off than a relief measure that also addresses horizontal inequality. A pragmatic solution to provide relief to hardship cases and low-income households is to combine equal-per-capita payments with hardship compensation (such as oil heating compensation and long-distance commuting compensation). Combining equal-per-capita payments with hardship compensation produces the least variability in burden across the different household types while simultaneously making poorer households better off.

Figure 1

The Vertical and Horizontal Inequality Dimensions of the Carbon-Price Burden



Source: Authors' compilation.

WELFARE-ECONOMICS BACKGROUND

Existing works on carbon pricing emphasize how labor income cuts and equal-per-capita lump-sum transfers can make carbon pricing progressive, addressing the vertical dimension (e.g., Boyce and Riddle 2007; Burtraw et al. 2009; Dorband et al. 2019; Klenert et al. 2018; Rausch et al. 2010). Horizontal equity effects are increasingly being studied from a descriptive rather than a normative perspective (e.g., Pizer and Sexton 2019). Hänsel et al. (2021) have developed a welfare-economics framework that incorporates the vertical and horizontal dimensions through differences in households' labor productivity and energy productivity. The latter heterogeneity addresses factors that are—in the short to medium term—exogeneous to households, and describe how much primary energy is needed to enjoy a certain utility level from energy-intensive services. Thus, horizontal inequality can be understood as a technological heterogeneity of housing capital, transport capital (cars, but also access to public transport networks), or climate conditions (affecting demand for energy). The implementation of a climate target and the corresponding carbon prices devalue these capital stocks, implying a differentiated carbon-price impact even within income groups.

If horizontal heterogeneity arises from exogenous factors, taxes, or transfers that are specific to the horizontal household type can eliminate any horizontal inequality effects from carbon pricing. The welfare economic analysis of Hänsel et al. (2021), however, emphasizes that, from a normative perspective, it is not optimal to eliminate all horizontal differences: because energy-efficient households can better convert an additional transfer to utility, diverting resources to energy-intensive households tends also to reduce aggregate welfare while horizontal equality increases. For a wide range of social inequality-aversion parameters, a large share of the horizontal inequality should be reduced—but not completely eliminated—by type-specific transfers.

While type-specific transfers constitute welfare-maximizing policies, they require household types to be observable. If the household type is non-observable, non-linear energy taxes are incentive-compatible second-best policies (Hänsel et al. 2021). But non-linear taxes require household-specific monitoring of energy consumption as the tax rate changes according to the amount of individual energy consumption. Because of the potentially high administrative costs of non-linear energy taxes, as well as household-specific transfers, it is crucial to identify institutionally feasible compensation schemes that address vertical and horizontal effects. If compensation schemes could be integrated into existing tax or transfers policies, transaction costs could be considerably reduced. The subsequent analysis therefore focuses on measures that could be implemented at low administrative costs in the German policy context.

EFFECT OF DIEFFERENT RELIEF MEASURES

This section assesses the carbon-price incidence for various relief measures for increased transport and heating oil prices for German households, based on data from the German sample survey on income and consumption (*Einkommens- und Verbrauchsstichprobe*), the environmental economic accounts (*Umweltökonomischen Gesamtrechnungen*), and the micro-census (*Mikrozensus*). The incidence calculation considers direct emissions and static household behavior (no behavior adjustment in response to changing prices). A detailed model description and data documentation are in Roolfs et al. (2021). The incidence calculation is also accessible online via http://www.mcc-berlin.net/co2preisrechner (in German).

We consider the following relief measures which recycle and redistribute carbon-price revenues to compensate households. German names are given in parentheses:

1. Equal-per-capita payment (*Pro-Kopf-Zahlung*): Each person receives an equal share of the carbon-price revenues.
2. Electricity price reduction (*Strompreis-Reduktion*): A revenue-neutral reduction of the renewable en-

ergy levy (*EEG-Umlage*)[1] reduces the electricity price. This is achieved by using carbon-price revenues to partially cover the funding objective of the levy.

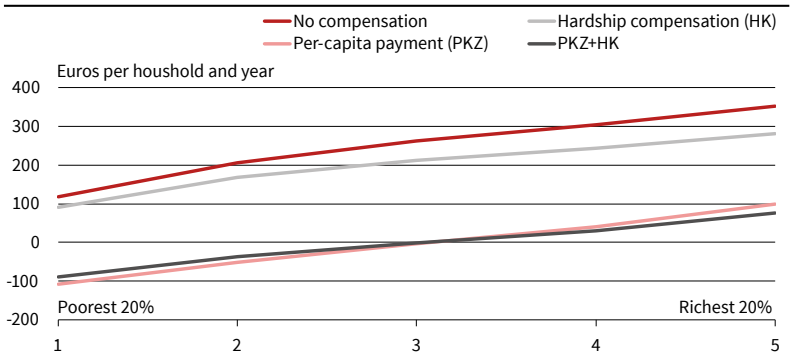
3. Long-distance commuting compensation (*Fernpendler-Kompensation*): Compensation for carbon-price related additional costs for households commuting more than 20 km. The compensation is independent of the travel mode, so it is also paid for by commutes by public transport or electric car and calculated from the average carbon emissions from one km traveled by car. It constitutes a modification of the existing commuting allowance of 30 eurocents per km that can be deducted from income tax.
4. Oil heating compensation (*Ölheizung-Kompensation*): Redistributes carbon-price revenues to households owning an oil heating system. Households are compensated by a fixed amount per year to exactly compensate the cost difference to an average household without oil heating. The compensation can be converted into an equivalent oil heating replacement subsidy to substitute heat pumps for oil heaters.
5. Landlord-pay regime (*Vermieter-Umlage*): Under this option, landlords cover 50 percent of tenants' heat-related carbon-price costs (i.e., natural gas and heating oil). This means that tenants are partially relieved of higher expenditures due to carbon pricing. The option is controversially discussed in Germany to increase incentives for landlords to reduce carbon emissions.[2]
6. Hardship-based compensation (*Härtefallkompensation*): Combines long-distance commuting compensation and oil heating compensation to address two important hardship cases (i.e., to avoid large horizontal inequality effects).

[1] The EEG (*Erneuerbare-Energien-Gesetz*) or Renewable Energy Sources Act is a series of German laws to encourage the generation of renewable electricity. It entails feed-in tariffs for renewable energy production. These tariffs are funded by the EEG levy (*EEG-Umlage*) raised from electricity consumers.

Figure 2

Relief Potential along the Vertical Inequality Dimension (Income) for Selected Compensation Measures

Absolute Burden on Private Households, Revenue Cycling Options (50 EUR CO_2-price)

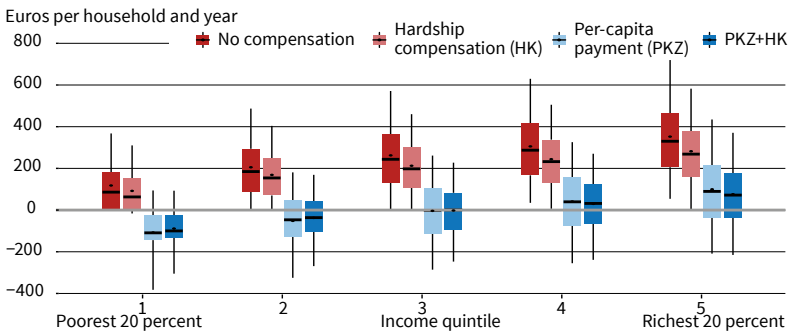


Source: Data from Einkommens - und Verbrauchsstichprobe (EVS), Umweltökonomische Gesamtrechnungen, and Mikrozensus; authors' calculation. © ifo Institute

Figure 3

Relief Potential along the Horizontal (CO_2 Intensity/Social Hardship) and Vertical (Income) Inequality Dimension

Absolute Burden on Private Households, Revenue Cycling Options (50 EUR CO_2-price)



Source: Data from Einkommens- und Verbrauchsstichprobe (EVS), Umweltökonomische Gesamtrechnungen, and Mikrozensus; own calculation. © ifo Institute

To compare the incidence of the carbon price by different relief measures, we also report the incidence without any compensation measures ("no compensation").

Starting with the vertical dimension, some compensation measures are generally assumed to positively impact low-income households. Among these are equal-per-capita payments, reduced electricity prices by lowering the renewable energy levy, and landlord compensation. Intuitively, one would expect a high relief for low-income households both from the landlord-pay regime (because landlords pay 50 percent of tenants' heat-related carbon-price costs) and with an electricity price reduction (because the share of electricity costs declines with household income).

Figure 2, however, suggests that equal-per-capita payments outperform both measures in terms of reducing the burden on low-income households, and the landlord-pay regime has almost no relieving effect. The reason is that equal-per-capita payments purely add to household income, while the electricity price reduction funded by carbon-price revenues also relieves parts of the industry that additionally benefit from a reduced levy. Similarly, the landlord-pay regime touches only a fraction of the burden imposed on low-income households by carbon pricing. The reason is that low-income households are not necessarily tenants and, if they are, 50 percent of the heat-related carbon price is not necessarily the largest cost item for them.

Figure 3 shows the distributional effects of two relief measures addressing vertical and horizontal effects. Whereas equal-per-capita payments primarily target income differences (vertical dimension), the hardship-based compensation aims at relieving CO_2-intensive households (horizontal dimension). As a reference, we plot the incidence without compensation (in red).

Both equal-per-capita payments and hardship-based compensation reduce the burden on all

[2] There seems to be some empirical support for such incentive effects in a United States case study, see Myers (2020).

Table 1

Relief Potential for Different Socioeconomic Groups for Various Compensation Measures for a Carbon Price of 50 EUR

	All house-holds	Long-distance commuter	Tenants	Urban areas	Rural areas	House-holds with car	House-holds with oil heating	Long-distance commu-ters with oil heating
Share of population (%)	*100*	*26*	*53*	*48*	*21*	*79*	*21*	*5*
No compensation	250	409	177	225	275	296	358	536
Landlord-pay regime	245	407	140	220	272	295	344	526
Long-distance commuting compensation	224	311	159	201	247	266	332	435
Oil heating compensation	224	383	156	203	131	268	233	411
Electricity price reduction	95	211	66	76	112	126	200	340
Long-distance commuting compensation + Electricity price reduction	85	133	59	68	100	113	190	258
Equal-per-capita payment	– 5	47	– 40	– 21	12	20	101	165
Long-distance commuting compensation + Equal-per-capita payment	– 5	– 16	– 37	– 20	10	17	100	101

Source: Data from Einkommens- und Verbrauchsstichprobe (EVS), Umweltökonomische Gesamtrechnungen, and Mikrozensus; own calculation.

income groups. Equal-per-capita payments relieve low-income households the most and produce a net gain for households in the lowest income quintile. This is a clear illustration of how equal-per-capita payments address the vertical dimension of inequality concerns related to carbon pricing. For hardship-based compensation, the burden for all income groups is reduced, but the measure does not produce a net gain for any income group. High-income households see the largest burden reduction. Low-income households receive the smallest relief compared to all income groups under the hardship-based measure. As a result, hardship-based compensation reduces the overall burden on households compared to no compensation, and reduces the burden spread across income groups, but it does not fully transfer carbon-tax revenues back to households. One solution to compensating hardship cases while achieving a progressive effect—with a large relief for low-income households—is to combine equal-per-capita payments with hardship compensation. To again be revenue neutral, the per-capita payments are reduced to reserve funds for hardship compensation. In this case, low-income households receive a net relief, and the burden increases progressively. Nevertheless, the burden spread is reduced compared with pure per-capita payments. The combination allows both vertical and horizontal equity aspects to be balanced.

Different compensation measures distribute the burden across socioeconomic groups differently, as Table 1 shows for a carbon price of 50 euros per ton. The color scheme helps to rank the burden. Red and orange shades represent “very large” and “large” burdens on respective socioeconomic groups. Yellow stands for a “medium” burden, and blue represents net gains of varying magnitudes. The compensation measures are ranked top to bottom in terms of their overall ability to relieve as many socioeconomic groups as possible.

Intuitively, no compensation always results in the most considerable burden for every household. Long-distance commuters with oil heating are hit the most under any compensation scheme. In terms of the overall population, per-capita payments and the combination of per-capita and long-distance commuting compensations outperform all other schemes. Long-distance commuters benefit most under the combination of per-capita and long-distance commuting compensations, which is a dramatic improvement for this group over the pure long-distance commuting compensation scheme. Tenants benefit most under per-capita payments, which are much better for this group than a landlord-pay regime. Rural areas are hit more than urban ones under all compensation schemes, except under an oil-heating-based compensation scheme where rural areas are better off. However, in absolute terms, compensation measures involving per-capita payments are vastly superior to all others for both urban and rural areas. Similarly, households with a car, those with oil heating, and long-distance commuters with oil heating all benefit most under per-capita payments or a combination of per-capita and long-distance commuting compensations. Lastly, we compare the performance of the combination of per-capita and long-distance commuting compensations with pure per-capita payments. Significant improvements can be achieved for long-distance commuters with oil heating if per-capita payments are combined with long-distance commuting compensation.

From the perspective of the horizontal inequality generated by carbon pricing and the relief measures, it is apparent that compensation schemes involving

per-capita payments also produce the least variability in burden across different household types. The distance from each type of household to the average household in the first column is smallest for compensation schemes involving per-capita payments. Overall, we can conclude that compensation measures involving equal-per-capita payments outperform other compensation schemes in terms of the resulting vertical as well as horizontal inequality. Nevertheless, as Figure 2 also illustrates, there is a trade-off between horizontal and vertical inequality reduction: pure per-capita payments would make low-income households better off than a policy that also addresses horizontal inequality.

PATHWAYS TO FAIR CARBON PRICES

The advantage of a carbon price is that it establishes a technology-neutral incentive for innovations in climate-friendly alternatives and for the reduction in the use of CO_2-intensive goods and technologies. But it also generates revenues that can be used to relieve the burden on citizens or the economy. In Germany, the revenues from national carbon pricing and from European emissions trading flow exclusively into the Energy and Climate Fund (*EKF*). In 2021, 40 percent of these funds will be used to reduce the renewable energy levy and thus ease the burden on private households and companies. In 2022, only 32 percent will be used for this purpose. The remaining revenue will be used for subsidy programs.

However, this analysis makes it clear that an increase in carbon prices can and should be combined with compensation schemes. In this way, the costs of climate protection can be fairly distributed and social hardship can be avoided with low or reasonable administrative efforts. Regarding the effect of relief measures, there are various misconceptions in the public perception that do not stand up to closer analysis. For example, it appears that a reduction in electricity costs and, even more so, a per-capita rebate can ensure a socially fair carbon price. In contrast, passing on part of the increased costs to landlords and raising the commuter allowance do not have a substantial relieving effect on poorer households.

Since significantly higher carbon prices—and thus also significantly higher costs for households—are needed to achieve ambitious climate targets, the share of direct relief measures should be increased. In the short term, this could be done using a further subsidy to finance the German feed-in tariff system for renewable energy supply and, in turn, lower the renewable energy levy. In the medium term, the legal and administrative conditions for direct reimbursements via per-capita payments could be created. Because renewable energy will become competitive when carbon prices rise sharply, the financing requirements via the renewable energy levy will decrease. Expenditure programs for CO_2-free infrastructure—for a hydrogen economy for example—could be financed by revenues from carbon pricing of the industry, while revenues from household pricing should increasingly be returned to households. Financial hardship for certain groups, such as long-distance commuters or households with oil-fired heating systems, could be prevented with low-cost time-limited compensation, without weakening the incentive effect of carbon pricing (see also the last row in Table 1). A socially just carbon price—even with high prices above 100 euros per ton—is possible and necessary.

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