Documentation of the CO_2-price incidence webtool[⋆,⋆⋆] «MCC CO_2-Preis-Rechner»

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Abstract

This document describes data, methods, and modeling used for the CO_2-price incidence webtool («MCC CO_2-Preis-Rechner») version 1.0, accessible at http://www.mcc-berlin.net/co2preisrechner. The webtool calculates the carbon price incidence of increased transport and heating fuel prices for German households and compares different relief measures using data from Einkommens- und Verbrauchsstichprobe, Umweltökonomische Gesamtrechnungen, and Mikrozensus.

Keywords: Documentation, carbon price, incidence, transfers, redistribution, Germany

⋆Funding from the Kopernikus-Projekt Ariadne (FKZ 03SFK5A) by the German Federal Ministry of Education and Research is gratefully acknowledged.
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Overview

The CO_2-price incidence tool («MCC CO_2-Preisrechner») calculates the direct costs of individual households given a specific carbon price and different relief measures. It estimates the carbon price incidence of increased transport and heating fuel prices in Germany based on household and expenditure data from the income and consumption survey «Einkommens- und Verbrauchsstichprobe 2018 (EVS18)», «Umweltökonomische Gesamtrechnungen (UGR18)», and «Mikrozensus» for commuting distances. This documentation describes version 1.0 which is publicly accessible at http://www.mcc-berlin.net/co2preisrechner. It explains various data processing steps to correct for seasonality, missing expenditure values and merging further data as well as the way we model costs and benefits of policies and compensation schemes.

Section 1 introduces the model and calculations used to derive the costs per household. Section 2 lists the relief measures considered, and Section 3 explains the data and data-processing.

1. Calculation of costs per household

The direct costs per year for each household $i = \{1, ..., N\}$ are defined as the sum of costs arising from the consumption of each energy source $j = \{$natural gas, heating oil, coal, district heating, gasoline, diesel$\}$:

$$C_i \equiv \sum_j C_{i,j}. \tag{1}$$

The costs for each household per energy source, $C_{i,j}$, are calculated by multiplying the effective tax rate τ_j by the quantity of CO_2-emissions for each energy source for each household, $E_{i,j}$ and accounting for the value-added tax. Thus, yearly costs per household and energy source are:

$$C_{i,j} = \tau_j \cdot E_{i,j} \cdot (1 + VAT). \tag{2}$$

The effective carbon price rate for each ton of CO_2 per energy source j equals the national carbon price p_{Nat}[1] :

$$\tau_j = p_{Nat}, \quad \text{if } j = \{\text{gasoline, diesel, coal, oil, natural gas}\} \tag{3}$$

The emission level for each energy source per household ($E_{i,j}$) results from the quantity of energy consumed by private households ($Q_{i,j}$) multiplied by the average carbon intensity of each energy source (I_j) :

$$E_{i,j} = Q_{i,j} \cdot I_j \cdot \epsilon, \tag{4}$$

where ϵ is the scaling factor that allows to capture future changes in emissions. For our analysis, we assume that the related emission targets stated in the German federal climate protection act (Bundesklimaschutzgesetz) will be met. The scaling factor is therefore calculated as the ratio between the target emissions and the actual emissions

[1] We do not set a carbon price for electricity and district heating, as these are already covered by the EU ETS.

in 2018 as obtained from Umweltbundesamt (UBA, 2021). Thus, we obtain a scaling factor for the year 2022 to capture reductions in CO_2-emissions, assuming that these reductions will be proportional in each sector.[2] To receive annual quantities of energy consumed for each household, we divide the yearly expenditures per energy source ($X_{i,j}$), as obtained from EVS18, by the respective average fuel price (P_j) in the given year. When estimating effective consumption quantities, we also take base fees (F_j) in gas, electricity and heating contracts into account:

$$Q^*_{i,j} = \frac{X_{i,j} - F_j}{P_j}. \tag{5}$$

These values are raw quantities and prone to various measurement and recall errors. In particular, they do not fully match 2018 macro data for Germany elicited by the Federal Statistical Office via the System of Environmental-Economic Accounting (Destatis, 2020b). Therefore, we scale the calculated energy consumption per fuel from EVS18 ($Q^*_{i,j}$) by energy consumption data from UGR (Destatis, 2020b):

$$Q_{i,j} = Q^*_{i,j} \cdot \frac{Q_j^{UGR}}{\sum_i^N Q^*_{i,j} w_i}, \tag{6}$$

where Q_j^{UGR} is the total quantity of energy consumed by private households in Germany according to Destatis (2020b). The weighting factor w_i is determined by the number of households in Germany represented by one respondent household in EVS18. Hence, the fraction is a scaling factor that adjusts the questionnaire response by aggregate numbers from Destatis (2020b).

2. Relief measures considered for Germany

The CO_2 price tool («MCC CO_2-Preis-Rechner») analyzes various relief measures. These measures recycle and redistribute carbon price revenues to compensate

[2]According to the German federal climate protection act, emissions in 2022 will decrease from 856 million tons CO_2e in 2018 to 756 million tons CO_2e in 2022. Thus, the scaling parameter is $\epsilon = \frac{756}{856}$.

households. To contrast the distributional effects, the tool also provides a benchmark scenario without relief measures (i.e., no compensation).

In the following, we indicate the calculation of the cost with and without relief measures. A short overview of all analyzed measures may be found at the end of this Section in Table 1.

1. **No compensation («Ohne Kompensation»):** CO_2-price revenues are not used to compensate households. Households bear the full burden of higher energy costs. The additional costs that each household has to bear (C_i) amount to

$$C_i^{NO} = \begin{cases} C_i & \text{if } B_i < 1200 \\ C_i - C_{i,Oil} - C_{i,Gas} & \text{if } B_i \geq 1200, \end{cases} \tag{7}$$

   where B_i is the amount of social welfare transfers in Euro received from the government. Social welfare recipients are defined as households receiving transfer benefits of more than 1200 € per year.[3] Their heating costs are covered by a heating cost subsidy («Heizkostenzuschuss») which also covers additional expenses due to carbon pricing. Social welfare recipients always benefit from the heating cost subsidy, regardless of how CO_2-price revenues are redistributed. Hence, this exemption also applies to all subsequent relief measures even if not explicitly shown in the respective formula.

2. **Per-capita payment («Pro-Kopf-Zahlung»)**: Each person receives an equal refund of carbon price revenues. This means that total costs (which are equal to total revenues) are divided by the size of the entire population. Each household receives a refund based on the number of persons living in the household.

$$C_i^{PKZ} = C_i - \frac{\sum_i^N C_i}{pop} \cdot H_i, \tag{8}$$

[3] We use this threshold to exclude households that received only social transfers for 1-3 months in that year.

where pop is the population size and H_i is the number of persons living in household i.[4]

3. **Electricity price reduction («Strompreis-Reduktion»)**: Reduction of the EEG-levy («EEG-Umlage»). A revenue-neutral reduction of the EEG-levy is achieved by using carbon price revenues to partially cover the funding objective of the EEG-levy. Effectively, this reduces the price per kWh of electricity consumed by households.

$$C_i^{SR} = C_i - Q_{i,elec}^{*} \cdot \frac{p_{Nat}}{10} \cdot s^{SR}, \tag{9}$$

where s^{SR} denotes a flat subsidy effectively reducing the price per kWh of electricity consumed. We calculate s^{SR} by dividing the revenues for a given carbon price, p_{Nat}, by the overall head of the EEG-levy («Förderhöhe»). This gives the share by how much percent the EEG-levy can be reduced. Thus, the reduction of the electricity price through a reduction of the EEG-levy per kWh is equal to s^{SR}.[5] A CO_2-price of 100 Euros fully covers the head of the EEG-levy. Hence, for CO_2 prices above this threshold, the additional revenues are not recycled to compensate households [6]

4. **Long-distance commuting compensation («Fernpendler-Kompensation»)**: Compensation of carbon-price-related additional costs for long-distance

[4]Note that this redistribution scheme is revenue-neutral in our model, but not from a macroeconomic perspective. Here, we only redistribute the revenues from a carbon price on households, but neglect any revenues from taxing firms. Thus, the revenues in our model are slightly lower than they would be when basing the computation on German macro data.

[5]To calculate s^{SR}, we took the head and the EEG-levy of the year 2020 (Bundesnetzagentur, 2019). This is due to the fact that from 2021 on the EEG-levy is already reduced by the revenues of the carbon price and thus biased downwards. The revenues from carbon pricing in 2022 are calculated by taking the relevant emission from the German federal climate protection act and multiply it with 10EUR/tCO_2. We also account for the value-added tax. Thus, the reduction of the EEG-levy per 10EUR CO_2-price is given by: $s^{SR} = \frac{\text{Revenue for 10EUR carbon price}}{\text{EEG-head}} \cdot \text{EEG-levy} \cdot 1.19 = \frac{2.9}{24.6} \cdot 6.756 \cdot 1.19 = 0.80 \cdot 1.19 = 0.95 \frac{ct}{kWh}$.

[6]Note that this redistribution scheme is revenue-neutral from a macroeconomic perspective but not within our household data set because our data set only contains household but not firm data. Since firms also benefit from a reduction of the EEG-levy, the redistributed benefits are not equal to the costs for this redistribution scheme in our model.

commuting households. It applies to those commuting a distance of 20km or more from the place of residence. Like the existing commuter allowance, the premium is independent of the travel method, so it is also paid for commutes by public transport or electric car. We calculate an average flat rate per km of $s^{FK} = 0.4165$ ct/km per 10 EUR carbon price.[7] The premium is paid to each commuter from the 21st km onward for each additional km commuted:

$$C_i^{VU} = \begin{cases} C_i & \text{if } d_i \leq 20 \\ C_i - s^{FK} \cdot \frac{p_{Nat}}{10} \cdot (d_i - 20) & \text{if } d_i > 20, \end{cases} \tag{10}$$

where d_i describes the distance to the workplace in km, while s^{FK} denotes the commuter allowance that is paid per km driven over 20km.

5. **Oil heating compensation («Ölheizung-Kompensation»):** Redistributes CO_2-price revenues to households owning an oil heating system. Households are compensated by a fixed amount of $s^{\text{ÖK}}$ per 10 EUR carbon price, resulting in:

$$C_i^{\text{ÖK}} = \begin{cases} C_i & \text{if } oil_i = 0 \\ C_i - s^{\text{ÖK}} \cdot \frac{p_{nat}}{10} & \text{if } oil_i = 1. \end{cases} \tag{11}$$

Here, oil_i is a dummy variable indicating if the household's primary heating source is an oil heating system. We set $s^{\text{ÖK}} = 25$, which is roughly equal to the mean additional burden an oil heating household has to bear in the no compensation scenario compared to an average household.

6. **Landlord-pay regime («Vermieter-Umlage»):** Under this option, landlords cover 50% of tenants' heat-related CO_2-price costs (i.e. natural gas and heating oil). This means that tenants are partially relieved of higher expenditures due to carbon pricing. We assume that in the short-run, the incidence of

[7] Assuming average gasoline consumption of 7 liters per 100km, an average carbon intensity for diesel and gasoline of 2.5 $kgCO_2$/l and a carbon price of 10 EUR plus the value added tax of 19%, the compensation is equal to $s^{FK} = 7 \cdot 2.5 \cdot 10 \cdot (1.19) \cdot 2 = 0.4165$ ct/km.

the pay-regime falls fully on land-lords and they cannot shift this to tenants in form of higher rental rates. Since tenants' heat-related carbon price payments are partially apportioned to landlords, households earning positive rental incomes or income from shareholdings in real estate groups bear a higher burden. Private households that own their residence are unaffected by this relief measure. Carbon price revenues are still not recycled to compensate households, as in the «no compensation» benchmark.

$$C_i^{VU} = \begin{cases} C_i & \text{if } rent_i = 0 \\ C_i - 0.5(C_{i,oil} + C_{i,gas}) & \text{if } rent_i = 1 \\ C_i + Y_i^{rent} \cdot \omega_1 & \text{if } Y_i^{rent} > 0 \\ C_i + Y_i^{shares} \cdot \omega_2 & \text{if } Y_i^{shares} > 0, \end{cases} \tag{12}$$

where $rent_i$ is a dummy variable indicating if a household lives for rent ($rent_i = 1$) or does not ($rent_i = 0$). Y_i^{rent} is a household's rental income and ω_1 is the share of the additional burden of carbon pricing for private landlords relative to total rental income. We calculate ω_1 by dividing the total costs private landlords have to bear, C^P, by the total amount of rent income of private landlords:

$$\omega_1 = \frac{C^P}{\sum_i^N Y_i^{rent}}. \tag{13}$$

For Germany in 2018, 46.47% of apartments are owned by the person living in it, 31.15% are let by private landlords and 8.08% are let by real estate groups (Destatis, 2019b). Resulting in a share of $\frac{0.3115}{(1-0.4647)} = 0.5819$ apartments which are not inhabited by the owner and let by private landlords. Thus, 58.19% of the heat-related costs of tenants have to be paid by private landlords. Costs for private landlords are given by:

$$C^P = 0.5 \cdot \sum_i^N \big((C_{i,oil} + C_{i,gas}) \cdot rent_i\big) \cdot 0.5819. \tag{14}$$

Y_i^{shares} is the household's income from corporate holdings in real estate groups and ω_2 is the share of the additional burden of carbon pricing for shareholders relative to total income from holdings in real estate groups. Analogous to ω_1, ω_2 is the total of tenants' carbon price costs faced by real estate groups, C^C, divided by the total amount of income from corporate holdings in real estate groups:

$$\omega_2 = \frac{C^C}{\sum_i^N Y_i^{shares}}. \tag{15}$$

Since 15.09% of all apartments which are not inhabited by the owner are rented by real estate groups ($\frac{0.0808}{(1-0.4647} = 0.1509$), this share of tenants' heat-related costs has to be paid by households with holdings in real estate groups such that

$$C^C = 0.5 \sum_i^N \big((C_{i,oil} + C_{i,gas}) \cdot rent_i\big) \cdot 0.1509. \tag{16}$$

Furthermore, 1.9% of all apartments are rented out by public institutions and 12.4% are rented out by building and housing cooperatives (Destatis, 2019b). These institutions will also cover half of the heating costs caused by their tenants, but these costs are not appointed to any households in our model.

The model allows to calculate the CO_2-price incidence of individual relief measures as well as combinations of measures. Table 1 summarizes the relief measures considered.

Relief measure	Acronym	Rule	Compensation
Equal per-capita payment (Pro-Kopf-Zahlung)	PKZ	Every person receives the same amount of the carbon price revenues per year.	$s^{PKZ} = 25.50$ EUR
Electricity price reduction (Strompreis-Reduktion)	SR	EEG-levy (incl. VAT) is partially covered by carbon price revenues.	$s^{SR} = 0.95 \frac{ct}{kWh}$
Distance commuting compensation (Fernpendler-Kompensation)	FK	Long distance commuters receive a premium for each km commuted over 20km to compensate travel costs.	$s^{FK} = 0.4165 \frac{ct}{km}$
Oil heating compensation (Ölheizung-Kompensation)	ÖK	Oil heating owners receive a flat subsidy per year.	$s^{\text{ÖK}} = 25$ EUR
Landlord pay regime (Vermieter-Umlage)	VU	Landlords cover 50% of tenants' heat-related carbon price costs.	$s^{VU} =$ variable

Table 1: Different redistribution parameters for carbon price relief measures per 10 EUR CO_2-price.

3. Data

In the following, we describe the data and sources for prices, carbon intensities and private household energy consumption in Section 3.1. Data pre- and post-processing steps for EVS18 and Mikrozensus 2016 are described in Section 3.2.

3.1. Prices, carbon intensities and household energy consumption

Unit	Electricity kWh	Gas kWh	Oil liter	Coal kg	Gasoline liter	Diesel liter	Heating kWh
Base Fee p.a. (F_j) in EUR	155**	160**	0	0	0	0	160**
Price (P_j) in EUR per unit	0.3019	0.065	0.694	0.2***	1.46	1.32	0.084
Carbon Intensity (I_j) in kg CO_2 per unit	0.468	0.2014	2.65	1.89	2.37	2.65	0.28**
Quantity (Q_j^{UGR}) in billion p.a.	128.81	315.69	13.49	1.35	23.64*	14.54*	60.61

*Data for 2017, ** Data for 2019, *** Data for 2021

Table 2: Prices, quantities, carbon intensities and base fess of different energy sources for private households in Germany in 2018.

Table 2 shows prices, quantities, base fees and carbon intensities for different energy sources consumed by private households in Germany in 2018. Price data is taken from the data base of the Federal Ministry for Economic Affairs and Energy (BMWI, 2020). This data base contains monthly average price data for each energy source except coal. For the price of coal, we imputed market prices of lignite observed in German hardware stores (see for example Hornbach or Bauhaus).

Quantity data for German household energy consumption of electricity, gas, oil and heating is taken from the «Umweltökonomische Gesamtrechnung» of the Federal Statistical Office (Destatis, 2020b) and converted into the units shown in Table 2. Data for gasoline and diesel consumption of private households is also taken from the data base of the Federal Statistical Office, but only available up until the year 2017 (Destatis, 2019a).

Carbon intensity for the electricity sector is taken from Umweltbundesamt (UBA, 2020). The carbon intensity of heating is taken from a fact sheet of the Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA, 2019). All other carbon intensities are physical constants and can be found via several sources.

Base fees are taken from the German price comparison website check24 and represent an average price for the year 2019.

3.2. Preprocessing EVS18

Before describing the preprocessing, we make some general remarks on the meta data. We use the EVS18 6(PERS) data set. Information on the meta data and included variables can be taken form the Scientific-Use-Files (FDZ, 2021a). The Federal Statistical Office provides publications with general information on household income, receipts, and expenditures (Destatis, 2020a).

3.2.1. Data processing steps

First, we multiply variables that refer to quarterly expenditures or incomes by four to obtain annual values whenever reasonable.[8] We confirmed these conjectures by running regressions using simple dummies for the quarters in which the respective households were interviewed. While expenditures on electricity, gas, and district heating are only slightly higher in the last quarter(s) of the year, the expenditures on heating oil and solid fuels significantly vary across quarters (see Figure A.1-A.5 in Appendix A).

Most notably, EVS18 contains information on various energy expenditures referring to the quarter in which the respective household was interviewed, including

[8] While extrapolating from quarterly values to annual values seems reasonable for expenditures on electricity, gas, and district heating (mostly due to fixed monthly payments committed to in contracts), it is not straightforward for heating oil and solid fuels such as wood, coal, or wood pellets as purchases here are lumpy. We estimate these expenditures therefore with different techniques, see below.

quarterly expenditures on electricity, gas, heating oil, district heating and hot water, as well as solid fuels. Further important variables are first, the *primary heating system* a household relies on (district heating, central heating, self-contained (story) central heating, or single-space/multiple-space oven) and second, the *primary energy type used for heating purposes* (electricity, gas, heating oil, solid fuels (e.g. wood, coal, or wood pellets), others (e.g. geothermal or solar energy), and not applicable (which corresponds to the use of district heating).

The needs of overall consumption goods of a household grow with each additional member, however, not proportionally. Instead, demand for electricity, housing space, durables etc. will not be four times as high for a household with four members than for a single person household due to economies of scales. We thus make use of equivalence scales allowing to assign each household type in the population a value in proportion to its actual needs. While a wide range of equivalence scales exists, we make use of the «OECD-modified scale». This scale assigns a value of 1 to the household head, of 0.5 to each additional adult member and of 0.3 to each child (below the age of 14). This allows to calculate adult equivalent household net incomes and private consumption. In turn, these are used to assign all households to adult equivalent income/expenditure deciles/quintiles of the population (while accounting for the frequency weights of the interviewed households).

3.2.2. Imputations

Electricity. For all households without any reported expenditures on electricity, we predict their actual expenditures by making use of the following regression (which is run using only those households with positive electricity expenditures which do not use electricity for heating purposes):

$$\begin{aligned} log(elec\_exp_i) =& \alpha + \beta_1 log(consump\_exp_i) + \beta_2 log(consump\_exp_i)^2 + \\ & \beta_3 log(housing\_space_i) + \beta_4 housing\_situation_i + \\ & \beta_5 house\_build\_year_i + \beta_6 housing\_type_i + \\ & \beta_7 house\_heating\_system_i + \beta_8 no\_members_i + \\ & \beta_9 regional\_state_i + \beta_{10} mie\_age\_group_i + \\ & \beta_{11} mie\_soceco\_status_i + \epsilon_i, \end{aligned} \tag{17}$$

where i denotes a household. Since the regression uses the logarithm of the outcome variable, we recalculate the predictions to obtain $elec\_exp_i$ also for those households without any reported electricity expenditures.

Gas. Similarly, we impute expenditures on gas for all households with zero reported expenditures despite having reported gas as the primary energy source for heating purposes. The respective regression is run on all households with positive expenditures on gas which also reported gas as being the primary energy source for heating purposes.

District heating. Since reporting «not applicable» for *primary energy source used for heating purposes* corresponds to reporting «district heating» as the *primary heating system* (with only a very small number of exceptions), we impute expenditures on district heating and hot water for all households with zero reported expenditures despite having reported «not applicable» for the *primary energy source used for heating purposes* (i.e. «district heating»for the *primary heating system*). To that end, we make use of the gas-regression mentioned in the previous subsection. The predicted expenditures on gas that households would roughly have if gas were used for heating purposes, are then converted into kWh (by dividing by the average price for gas in 2018) and in turn converted back into EUR (by multiplying by the average price for district heating in 2018).

Heating oil. As initially mentioned, we cannot reliably extrapolate from quarterly expenditures on heating oil to annual expenditures for several reasons. First, most households buy heating oil in later quarters of the year, leading to reported expenditures of zero if interviewed in earlier quarters. Second, since the demand for heating oil naturally varies across quarters, so does its price. Lastly, depending on how much oil is still in the oil tank, some households need to buy more while others only need to buy a small amount of oil. For these reasons, we do not use any of the reported (quarterly) expenditures on oil to obtain annual expenditures. Instead, as in the case of district heating, we make use of the gas-regression mentioned earlier to first predict expenditures on gas that households would roughly have if gas were used for heating purposes. These are then converted into kWh (by dividing by the average price for gas in 2018) and in turn converted back into EUR (by multiplying by the average price for heating oil in 2018).

Solid fuels. Quarterly expenditures on solid fuels (such as wood, coal, or wood pellets) cannot be simply extrapolated to annual expenditures for similar reasons as in the case of heating oil. Hence, we also do not use any of the reported (quarterly) expenditures on solid fuels to obtain annual expenditures. Instead, we again make use of the gas-regression to first predict expenditures on gas that households would roughly face if gas were used for heating purposes. These are then converted into kWh (by dividing by the average price for gas in 2018) and in turn converted back into EUR (by multiplying by the average price for solid fuels in 2018).[9]

Summary statistics. In the end, only households which reported «Electricity» or «Others (e.g. geothermal or solar energy)» as their *primary energy type used for heating purposes* can (in principle) remain without any expenditures on gas, heating oil, district heating, or solid fuels.

The distribution of expenditures on all energy types (after having performed all the above data-processing steps) is depicted in Figure B.6-B.11 of Appendix B.

3.2.3. Commuting distances

Since the EVS18 does not contain any information on the commuting distances of households, we attempt to incorporate them by resorting to a different data source: the Mikrozensus 2016 (FDZ, 2021b).

Mikrozensus 2016. Mikrozensus 2016 provides information on the the commuting distances for every member of the interviewed households. However, since this information is only available in the form of a categorical variable with intervals ranging from 0 to below 5 km, 5 to below 10 km, 10 to below 25 km, 25 to below 50 km,

[9]Here, we need to make a strong assumption on the average price for solid fuels because solid fuels comprise wood, coal, and wood pellets.

and 50 km and more (plus «0», «not specified», and «permanently changing working place»), we convert these responses into a numeric variable by using a simple approach: For each of the specified commuting distance intervals above 0 and below 50 km, we draw a single value (i.e. a commuting distance) within that interval from a uniform distribution. While we keep 0 km for those that reported 0 km, we pick the average commuting distance in the population (i.e. 11 km) ± a random draw from a normal distribution with mean of 0 and a standard deviation of 1 for those reporting a «permanently changing working place». We proceed similarly for those reporting to be part of the workforce but no specified commuting distance. Lastly, we set the commuting distance to 0 km for all households reporting to be no active part of the workforce and no specified commuting distance. Having done this, we add up the commuting distances for each household member to finally obtain total commuting distances per household.

EVS18. We proceed to our approach for Microzensus commuting data with EVS18 in that we add up the expenditures for transport fuels (gasoline and diesel) and transport services (including train, road, aviation, combined modes of transportation, as well as other modes of transportation).

'Matching' Mikrozensus 2016 and EVS18. For both data sets, we collect the information on (1) the income decile (using the adult-equivalent household net income), (2) the number of household members in the workforce («none», «one», «one or more»), and (3) the region in which the respective households reside. For the latter, we combine the following regional states: Baden-Württemberg or Bayern; Hessen, Rheinland-Pfalz or Saarland; Nordrhein-Westfalen; Schleswig-Holstein or Niedersachsen; Thüringen, Sachsen, Sachsen-Anhalt, Brandenburg or Mecklenburg-Vorpommern; and Hamburg, Bremen or Berlin.

Subsequently, we group the households included in Mikrozensus 2016 by these three variables and allocate each of the households in commuting distance deciles (depending on their group). Next, we group the households included in EVS18 by these three variables and allocate each of the households in transport expenditure deciles (depending on their group). In a final step, we match the households in

Mikrozensus 2016 and EVS18 based on the three variables and the newly created commuting distance/transport expenditure deciles and ultimately store the average commuting distance for each of the respective groups.

3.2.4. Income from capital and assets

The landlord-pay-regime imposes the costs of carbon pricing partly to landlords who rent out housing space. This also applies to real estate companies. We assume that these costs reduce profits of real estate companies which ultimately lead to reduced capital incomes of households. As we do not have information on the specific financial portfolio of households, we assume that households have the identical well-diversified portfolio and the costs of the landlord-pay-regime is therefore proportional to capital income from financial assets. To obtain a unique variable containing information on the *annual income from capital and assets*, we proceed as follows: First, we multiply the *quarterly income from interests*, the *quarterly income from dividends*, and the *quarterly income from distributions* by four and subsequently add up all these variables to obtain a variable containing information on the *annual income from capital*. Second, we multiply the *quarterly income from sales of securities* and the *quarterly income from sales of shares* by four and subsequently add them up to obtain a variable containing information on the *annual income from assets*. To make *annual income from assets* comparable to *annual income from capital*, we multiply the former by the *average market return* (here 6%). Third, we add up both (comparable) variables to obtain a variable containing information on the *annual income from capital and assets*.

Appendix A. Original Data

Figure A.1

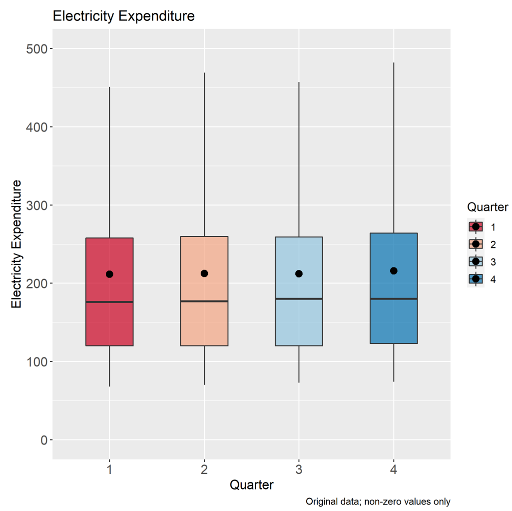


Figure A.2

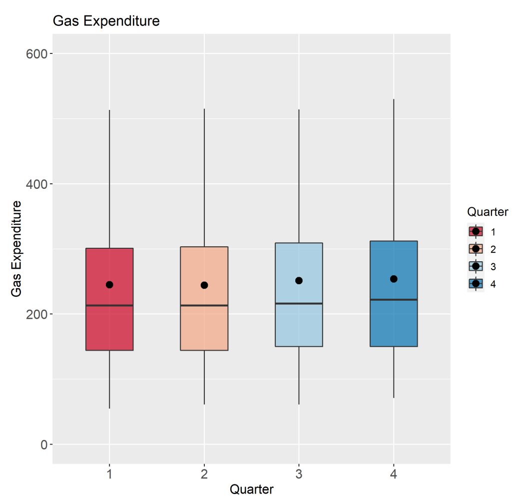


Figure A.3

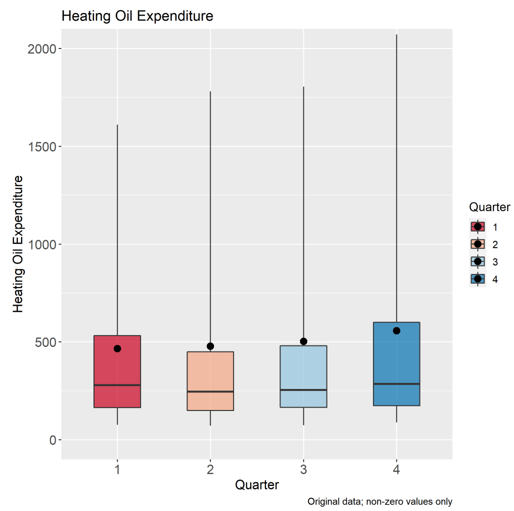


Figure A.4

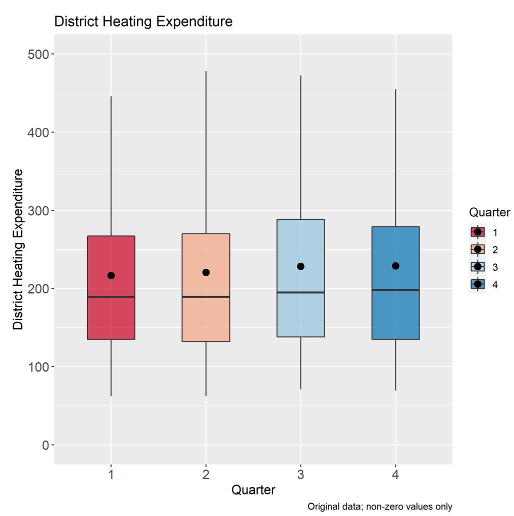
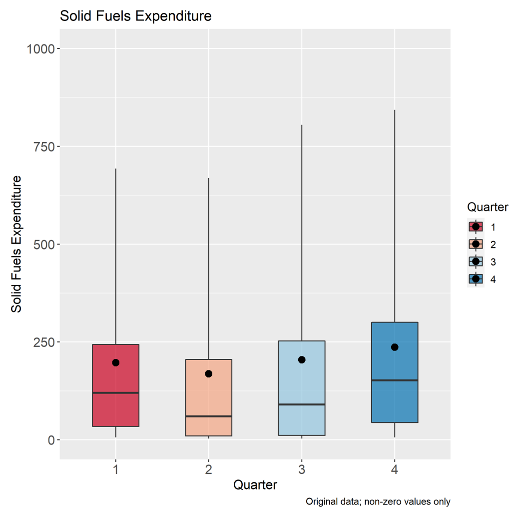


Figure A.5


Solid Fuels Expenditure
1000
750
500
250
0
Solid Fuels Expenditure
1
2
3
4
Quarter
Quarter
1
2
3
4
Original data; non-zero values only

Appendix B. Post-processed Data

Figure B.6

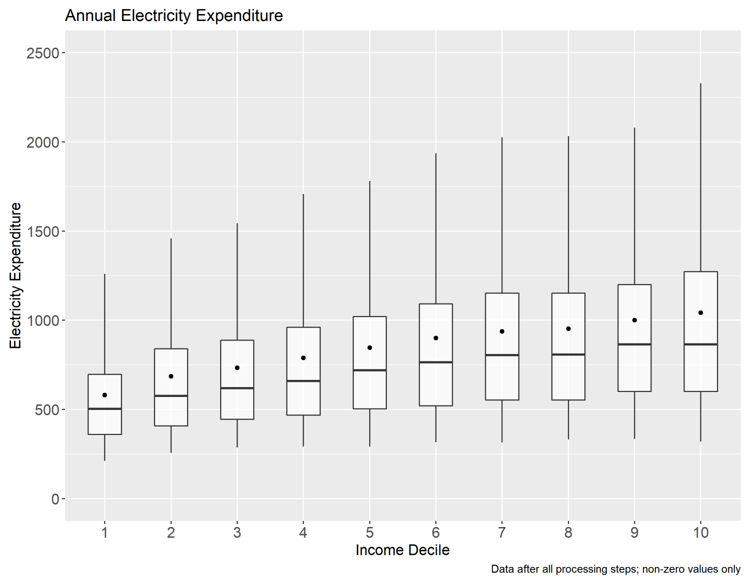


Figure B.7

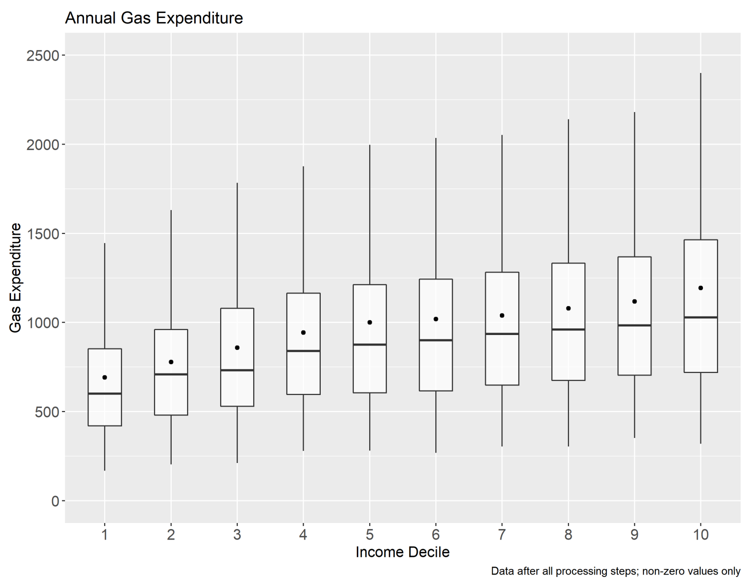


Figure B.8

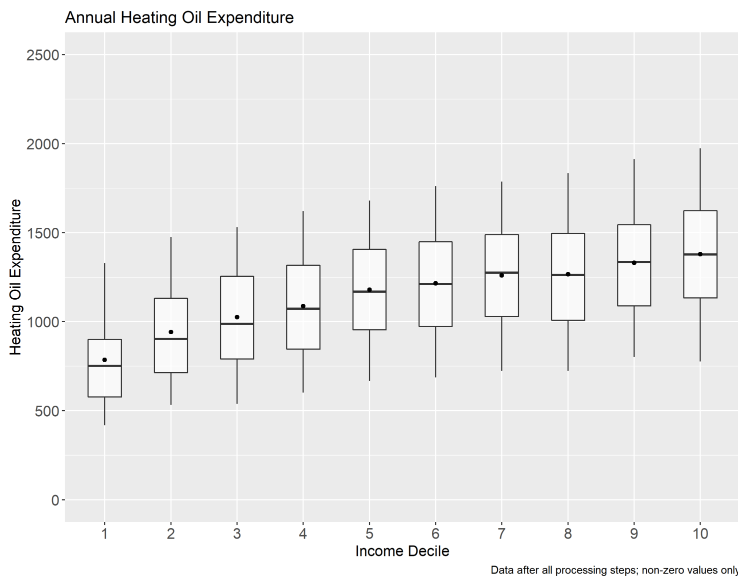


Figure B.9

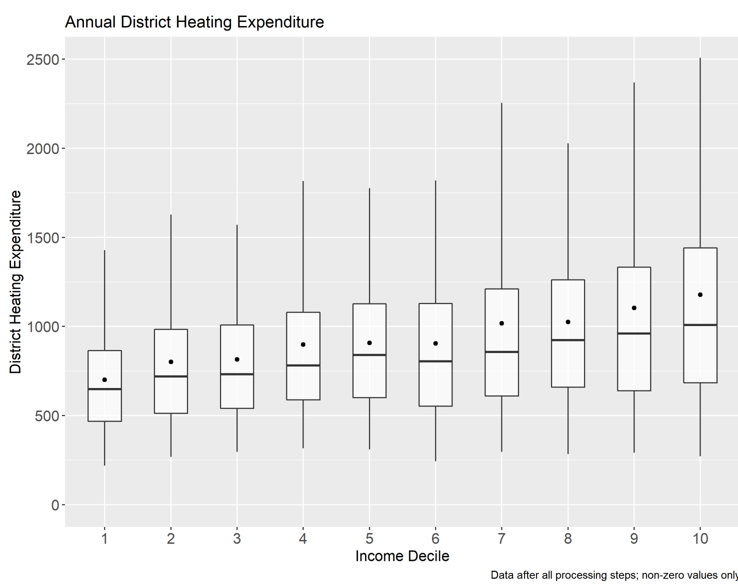


Figure B.10

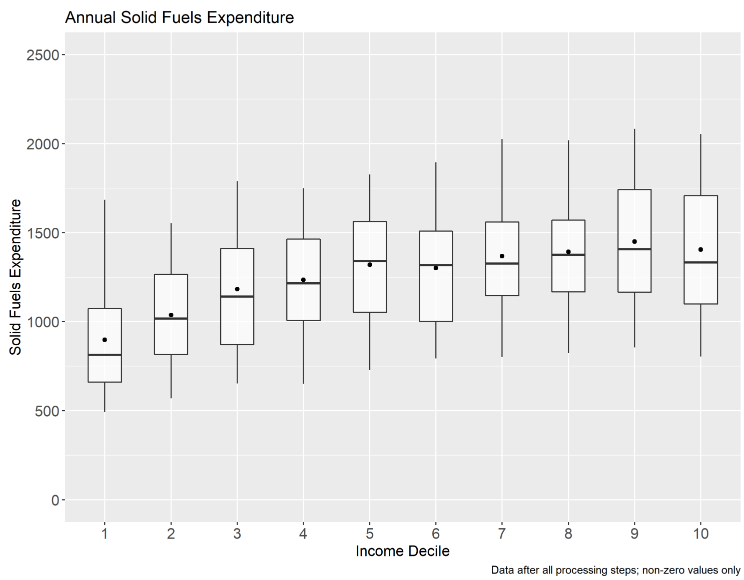
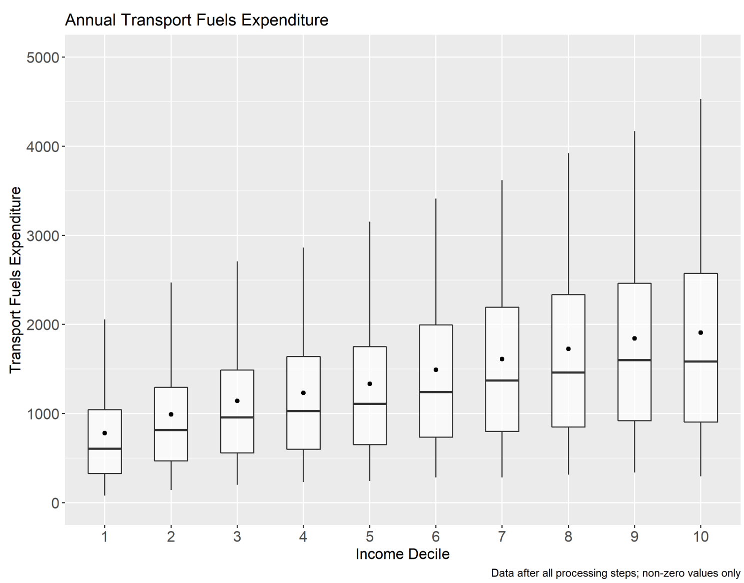


Figure B.11



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