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# Rebound effects may jeopardize the resource savings of circular consumption: evidence from household material footprints

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## Abstract

The circular economy model aims to reduce the consumption of virgin materials by increasing the time materials remain in use while transitioning economic activities to sectors with lower material intensities. Circular economy concepts have largely been focussed on the role of businesses and institutions, yet consumer changes can have a large impact. In a more circular economy consumers often become users – they purchase access to goods and services rather than physical products. Other consumer engagement includes purchasing renewable energy, recycling and using repair and maintenance services etc. However, there are few studies on whether consumers actually make these sorts of consumption choices at large scale, and what impacts arise from these choices on life-cycle material consumption. Here we examine what types of households exhibit circular consumption habits, and whether such habits are reflected in their material footprints. We link the Eurostat Household Budget Survey 2010 with a global input-output model and assess the material footprints of 189,800 households across 24 European countries, making the results highly generalizable in the European context. Our results reveal that different types of households (young, seniors, families etc.) adopt different circular features in their consumption behaviour. Furthermore, we show that due to rebound effects, the circular consumption habits investigated have a weak connection to total material footprint. Our findings highlight the limitations of circular consumption in today's economic systems, and the need for stronger policy incentives, such as shifting taxation from renewable resources and labour to non-renewable resources.

## Introduction

Global material consumption has continued to increase in recent decades, with growth accelerating faster during the 2000s (Schandl et al., 2017). Given deep concerns surrounding unsustainable resource use, the circular economy has been suggested as an alternative to the traditional linear model of production, consumption and disposal. Circular economy approaches aim to decrease the virgin material inputs and the waste material outputs by slowing, closing and narrowing both material and energy loops, while maintaining economic growth (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). The circular economy has a strong emphasis on the role of private sector and new business models (Geissdoerfer et al., 2017; Camacho-Otero et al., 2018; Manninen et al., 2018). However, individual consumers can support circularity through their consumption choices.

The role of the consumer in the circular economy has been discussed from several perspectives. The dominant perspective is to shift the role of the consumer towards that of a user (Ellen MacArthur Foundation, 2013; Tukker, 2015; Ghisellini et al., 2016). Instead of ownership, circular economy approaches highlight "collaborative consumption" (Belk, 2014), "product-service systems" (Mont, 2002; Tukker, 2015) and “access-based consumption” (Bardhi & Eckhardt, 2012). In all these models, consumers have access to the needed goods and services, but don’t own them. Online and mobile platforms have increased the possibilities of collaborative consumption (Belk, 2014; Perren & Grauerholz, 2015), but traditional rental and leasing services can also contribute (Ellen MacArthur Foundation, 2013; Tukker, 2015). In addition to collaborative consumption, consumers can promote a circular economy by choosing products that are designed for longevity and recyclability, using maintenance and repair services, sorting and recycling their waste, replacing fossil fuel -based energy sources with renewables, and much more. However, there are few large-scale studies on whether consumers make circular consumption choices in practice, and whether these habits depend on socioeconomic characteristics or the level of urbanisation. Urbanisation has been suggested to increase the potential of sharing- (Fremstad et al., 2018) and circular economies (Su et al., 2013; Ghisellini et al., 2016) due to the spatial proximity of businesses and people in cities.

Previous empirical studies on circular consumption behaviour have focused on the barriers and motivators of consumer action (Camacho-Otero et al., 2018). Yet, the review of Camacho-Otero et al. reveals studies lack a direct connection to the actual environmental impacts of consumption. Particularly absent are holistic indicators that assess overall environmental impacts including rebound effects. An important holistic indicator is the environmental footprint (Steinmann et al., 2017; Wiedmann & Lenzen, 2018). An environmental footprint captures the life-cycle environmental impacts caused by the production of goods and services and allocates these impacts to the end-consumer. Steinmann et al. (2017) highlight that even relatively simple resource footprints (e.g. water, energy, material) can be highly representative of environmental damage.

An intrinsic benefit of footprint methods is that they include rebound effects (Ottelin, 2016). Rebounds originate when environmental actions cause monetary savings or require investments, which leads to changes in other types of consumption. Depending on their direction and strength, rebound effects can either increase or decrease the level of environmental impacts on net (Font Vivanco & van der Voet, 2014; Ottelin, 2016). Rebound effects in circular economy have been theorized (Zink & Geyer, 2017; Figge & Thorpe, 2019), and shown in practice for individual products (Makov & Font Vivanco, 2018). However, there are no previous studies concentrating on household level rebound effects related to circular consumption.

While the concept of the circular economy does cover energy and greenhouse gas emissions, its focus is on material cycles (Haas et al., 2015; Geissdoerfer et al., 2017). For this reason, we use the consumer material footprint here. Several studies have examined consumer material footprints (e.g. Lettenmeier et al., 2014, López et al., 2017; Junnila et al., 2018) but they are not as widely studied as consumer carbon footprints. Different types of indicators have been used under the term “material footprint”. These include the “material input per unit of service” (MIPS) -method (Lettenmeier et al., 2014; Laakso & Lettenmeier, 2016;  Buhl et al., 2019), and environmentally extended input-output (EE IO) analysis (López et al., 2017; Ottelin et al., 2018; Pothen & Reaños, 2018; Jiang et al., 2019). MIPS is based on process life cycle assessment and includes unused raw material extraction (RME) (e.g. waste rock in mining and logging residuals). EE IO analysis is another life cycle method that covers upstreams more comprehensively but is less accurate at individual product level (Piñero et al., 2018). EE IO studies sometimes include unused RME but not uniformly. Including the unused RME can increase material footprints significantly (Ottelin et al., 2018). However, it can be misleading, because the amount of the unused RME doesn't necessarily correlate well with the environmental damage caused (Wiedmann et al., 2015, SI), making comparisons between countries or different groups of consumers less meaningful. In this study, we follow Giljum et al. (2014), Wiedmann et al. (2015) and Ivanova et al. (2016), and define material footprint as consumption based RME, including only materials taken into the direct use of the economy. In addition, we focus on household consumption alone, and exclude public consumption and investments.

Previous studies on consumer material footprints have focused on the relationship between various socioeconomic factors and the footprints (Lettenmeier et al., 2014; López et al., 2017; Pothen & Reaños, 2018; Buhl et al., 2019). Junnila et al. (2018) is perhaps the only consumer material footprint study framed specifically with circular economy. They test the impact of reduced ownership on material- and carbon footprints of Finnish consumers. However, sustainable consumption more generally has been discussed and examined by many consumer material footprint studies. For example, Buhl et al. (2019) examine the impact of environmental attitudes on German material footprints. Laakso and Lettenmeier (2016) provide an interesting experimental study including five Finnish households. They study how the material footprints of these households are reduced through various efforts, such as vegetarian diets and reduced driving. Yet, there is a lack of large-scale studies investigating the impacts of circularity on material footprints.

In this study, we aim to fill these gaps by examining what types of households exhibit circular consumption behaviour, and how this is reflected in their material footprints. In other words, we combine the analysis of circular consumption patterns with the material footprint analysis, thus providing new insights that either analysis alone could not deliver. Furthermore, we analyse the connection between selected circular consumption indicators and material footprints, and examine what sorts of rebound effects may occur. The study is based on Eurostat's Household Budget Survey (HBS) 2010 and covers 189,800 households in 24 European countries. We combine the HBS with the global multi-regional input-output (MRIO) model Exiobase 2015. We aim to answer the following questions: 1) What household types exhibit a) circular- and b) linear consumption behaviour? 2) Is circular consumption associated with lower material footprints? and 3) Are there significant rebound effects related to the found circular consumption habits?

## Material and methods

### Research design

The research questions were addressed with three different analyses (Figure 1). First, we examined the relationship between socioeconomic variables and circular- and linear consumption behaviour. To do this we defined circular- and linear consumption indicators based on circular economy literature and the Eurostat HBS in 2010. In particular, we are interested in how life stage (young, families with children, seniors etc.) is related to consumption habits. In addition, we covered education, age, gender and the degree of urbanisation in the analyses. Secondly, we created a material footprint model, and analysed whether circular consumption features of different household types are reflected in their material footprints. Thirdly, we studied the connection of selected circular consumption habits to consumer material footprints, and examined potential rebound effects. We used multivariable regression analysis as the main method of analysis in all phases.

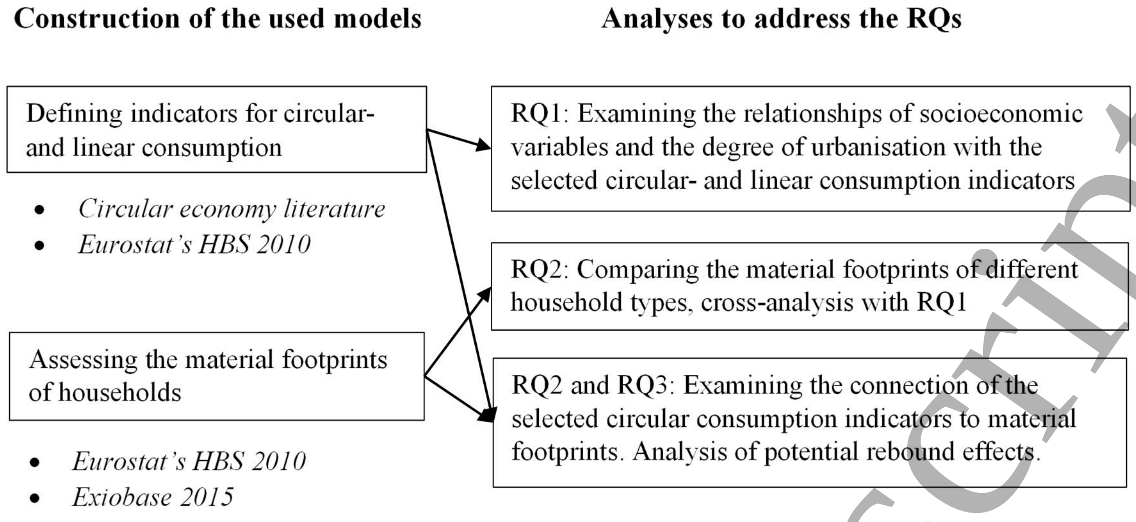


Figure 1. Research design

In the following sub-sections, we first present the used research material and material footprint model. Second, we describe the process of selecting suitable indicators for circular- and linear consumption. The selection was based on circular economy literature but limited by data availability. Third, we present the regression models and variables used in the consumption behaviour analyses (based on expenditure data alone). Finally, we describe the research settings and regression models used in the material footprint analyses, covering the relationship of socioeconomic variables, the degree of urbanisation, and circular consumption indicators with material footprints.

## Research material

The study is based on two datasets: Eurostat's Household Budget Survey (HBS) in 2010, and a global multi-regional input-output (MRIO) model, Exiobase 2015 (Tukker et al., 2014). The HBS includes detailed household expenditures, and information on household characteristics, residential location and socioeconomic status across EU member states. The main purpose of the survey is to provide general information about consumption and living conditions in the EU region. The HBSs are conducted voluntarily by member states around every five years. Since they are voluntary, member states themselves decide how to organize data collection. Thus, despite aiming to harmonise survey data between member states, there are still inconsistencies, which should be considered when using the survey data and interpreting results. The total sample size of the HBS 2010 is 275,000 households across 26 countries. However, due to data limitations, here we calculate material footprints for 189,800 households across 24 European countries. The country specific sample sizes and country abbreviations are provided in Table A1 in the appendix.

Environmental MRIO models are based on national accounts. They include monetary transaction matrices between countries and economic sectors, and satellite accounts for environmental indicators. Here we select Exiobase due to its high sectoral resolution, and because of its European focus. Exiobase 2011 is publically available at: https://www.exiobase.eu/. However, in this study we use a more recent version, Exiobase 2015, which reflects better current production technologies. Exiobase includes 44 countries and 5 "rest of world" regions, 200 products, and numerous different environmental indicators. The aggregate indicator for "Domestic Extraction Used" alone is divided into 227 different materials. However, for the purpose of the study, we summed these to one indicator.

## Material footprint model

Material footprints can be calculated by using environmentally extended input-output (EE IO) analysis (Giljum et al., 2014; Wiedmann et al., 2015). EE IO model is used to calculate the material intensities (kg/€) of economic sectors or specific products. The material footprint of a product can then be calculated by multiplying its price with the corresponding material intensity. In this study, the 200 different Exiobase products were matched with the COICOP classification (Classification of Individual Consumption by Purpose) as used in the HBS. The concordance matrix was constructed by following Ivanova et al. (2016), with small modifications. Some Exiobase categories used by Ivanova et al. have no household final demand in the 2015 Exiobase model used in this study. We replaced these with suitable categories that have (see the supplementary material for the concordance matrix). We used consumption category specific inflation coefficients (Eurostat 2020a) and price statistics (Eurostat 2020b) to transform the intensities of different sectors from 2015 to 2010 euros, and from basic prices to purchaser prices, in order to match them with the HBS data. As a result, our material footprint model is based on the economic structure and technologies in 2015, but consumption behaviour in 2010, because the Eurostat HBS 2015 was not yet available when the study was conducted. There have probably been some small changes in consumption behaviour from 2010 to 2015, but this is unlikely to affect our main findings.

Following Giljum et al. (2014), Wiedmann et al. (2015) and Ivanova et al. (2016), we used the consumption-based domestic raw material extraction, excluding unused materials, as the material footprint. The materials include biomass, fossil fuels, metal ores, and non-metallic minerals. We further exclude the material footprint of public consumption and investments, because these are not possible to allocate fairly to individual households without additional data. The unit of analysis in our study is the individual consumer (per capita).

Construction materials posed an issue because while its material intensity is generally quite high there is no suitable match for it in the HBS. Unlike the HBS of some individual countries, Eurostat's HBS does not include information on housing type, living space ($m^2$), or building materials. It only includes the expenditure on rentals and imputed rentals, housing energy and housing maintenance. Due to this data limitation and since the focus of this study is to compare different households, rather than estimate the overall material footprint, we choose not to use an average material footprint of construction for all households, or any other proxy. Consumer material footprints presented here will therefore be somewhat lower compared to previous studies. Because of this limitation, we could not test the connections between housing related circular consumption habits and material footprints. However, Junnila et al. (2018) provide some previous results on these.

## Selecting indicators for circular- and linear consumption

We used circular economy literature to identify key circular actions that can be translated into consumer behaviour. In addition, we identified linear, "Take-Make-Dispose", actions (see Table 1). Most importantly we rely on two previous literature reviews by Ghisellini et al. (2016) and Geissdoerfer et al. (2017), who reviewed 1031 and 362 studies on circular economy respectively. In addition, we put emphasis on the Ellen McArthur foundation's report "Towards circular economy"

(2013), which is highly cited in this field. Thus, these three references are specifically cited in Table 1 regarding the characteristics of circular- and linear consumption.

In this study, we matched COICOP consumption categories with the identified characteristics of circular- and linear consumption (Table 1) in order to create practical indicators to be used in the regression analyses. We found matching consumption categories for most of the identified characteristics, but not all. The COICOP classification, used broadly for HBSs around the world, does not provide information about the quality of the purchases. Thus, there is no information about whether the products are designed for longevity, have a green product label or are bought second-hand. There is also no information about households' waste sorting and recycling. These areas should be seen as a priority for addition in both the COICOP classification and in expenditure surveys if we are to increase our understanding of environmental consumption behaviour.

Based on Table 1, we created the following indicators for circular- and linear consumption behaviour (respective COICOP categories in parenthesis). Many of these consumption categories are relatively small, and there are a lot of households for which there is no expenditure in these categories. Thus, these indicators were used as dummy (binary) variables, meaning that 1 corresponds to having expenditure in the category, and 0 corresponds to having no expenditure in the category. However, for maintenance, meat products, services and tangibles, we used a continuous variable (expenditure in euros), since almost all households have some expenditure in these broad consumption categories.

*Indicators for circular consumption*

1. Repair and hiring services (0314; 0322; 0533; 05414; 0915; 0923), dummy
2. Refurbishing of housing and furniture (043; 0513), dummy
3. Public transport (0731; 0732), dummy
4. Rental housing (041), dummy
5. Services (health, culture, sport, restaurants, hotels etc.), continuous
6. Maintenance of housing (043; 056), continuous
7. Vegetarian diet (no expenditure on meat products: 0112), dummy

*Indicators for linear consumption*

1. Motor fuels (0722), dummy
2. Air travel (0733; 096), dummy
3. Purchase of motor vehicles (0711; 0712), dummy
4. Tangibles (cloths, electronics, furniture, equipment, toys etc.), continuous
5. Meat products (0112), continuous
6. Waste management services (0442), dummy and continuous

It should be noted that these indicators are not exhaustive and represent only a small portion of potential consumer actions. Nonetheless, they cover several aspects of circular economy. Repair, hiring, refurbishing, maintenance and rental services are most clearly circular as defined by previous literature on circular economy. Here we consider public transport as part of collaborative and access-based consumption. Since the production of vegetarian food is much more resource and environmentally efficient than the production of meat products (Tukker et al., 2011; Hallström et al., 2015; Scherer & Pfister, 2016), we consider a vegetarian diet as circular-, and the consumption of meat products as linear consumption. Furthermore, we use lumped services as one indicator for circular consumption. Although not all services are circular in the sense that they would directly substitute the use of products, the expenditure in services reduces the overall expenditure on products (assuming constant total expenditure). However, transport services are not included in the services here. Particularly, car rentals, and the repair and maintenance of cars, are not included in the services, nor in the sub-category "repair and hiring services". The used division of different consumption categories is provided as supplementary information.

Table 1. Characteristics of circular- and linear consumption, and matching them with COICOP consumption categories

| | | Circular consumption | | | | | | | | | Linear consumption | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consumption characteristics | | Longevity | Maintenance | Repairing | Reusing | Refurbishing | Recycling | Collaborative consumption | Renewable resources | Resouce efficiency | Premature obsolescence | Disposal | Fossil fuels, inefficiency | Ownership |
| Description | | *Products that have been designed for longevity instead of quick dispose* | *Maintenance services, tools and materials for maintenance* | *Repair services, tools and materials for repairing* | *Second-hand items* | *Refurbishing services, tools and materials for refurbishing* | *Waste sorting and recycling* | *Leasing, rental, sharing* | *Renewable energy and materials* | *Material efficiency, energy efficiency, green product labels etc.* | *Fast fashion, electronics, decorating* | *Waste generation* | | *Ownership of goods instead of rental and sharing* |
| Main references | | 1, 3 | 1, 3 | 1, 2, 3 | 1, 2, 3 | 1, 3 | 1, 2, 3 | 1, 2 | 1, 2 | 1, 2, 3 | 1 | 1, 2, 3 | 1, 2 | 1, 2, 3 |
| Consumption category in HBS | COICOP | | | | | | | | | | | | | |
| Cleaning, repair and hire of clothing | 0314 | | | x | | | | x | | | | | | |
| Repair and hire of footwear | 0322 | | | x | | | | x | | | | | | |
| Actual rentals for housing | 041 | | | | | | | x | | | | | | |
| Maintenance and repair of the dwelling | 043 | | x | | | x | | | | | | | | |
| Refuse collection | 0442 | | | | | | | | | | | x | | |
| Repair of furniture, furnishings and floor coverings | 0513 | | | x | | x | | | | | | | | |
| Repair of household appliances | 0533 | | | x | | | | | | | | | | |
| Repair of glassware, tableware and household utensils | 05414 | | | x | | | | | | | | | | |
| Goods and services for routine household maintenance | 056 | | x | | | | | | | | | | | |
| Motor-cars | 0711 | | | | | | | | | | | | | x |
| Motor-cycles | 0712 | | | | | | | | | | | | | x |
| Fuels and lubricants | 0722 | | | | | | | | | | | | x | |
| Passenger transport by railway | 0731 | | | | | | | x | | x | | | | |
| Passenger transport by road | 0732 | | | | | | | x | | x | | | | |
| Passenger transport by air | 0733 | | | | | | | | | | | | x | |
| Repair of audiovisual, photographic and information processing equipment | 0915 | | | x | | | | | | | | | | |
| Maintenance and repair of other major durables for recreation and culture | 0923 | | x | x | | | | | | | | | | |
| Package holidays | 096 | | | | | | | | | | | | x | |
| Tangibles | - | | | | | | | | | | | | | x |
| Services | - | | | | | | | x | | x | | | | |
| Meat products | - | | | | | | | | | | | | x | |
| Indicators in HBS (yes/no) | | No | Yes | Yes | No | Yes | No | Yes | No | Yes | No | Yes | Yes | Yes |

1. Ellen MacArthur Foundation, 2013; 2. Review by Ghisellini et al., 2016; 3. Review by Geissdoerfer et al., 2017

## Regression models for circular- and linear consumption

In order to examine the socioeconomic drivers of the selected circular- and linear consumption indicators, we used a multivariable regression analysis. We created two sets of models. With the first we examined the connections of life phase and the degree of urbanisation to consumption. With the second, we analysed education and gender, and used household size and age as control variables. Since life phase is usually a combination of household size and age, we did not include it in models that included household size and age. However, we added the degree of urbanisation in both sets of models to observe whether the models yield similar results (they did, which suggests that life phase is an appropriate variable to cover both age and household size simultaneously).

The logit models (for binary consumption variables) used in the study are as follows:

$$P(\text{expenditure on commodity } n > 0) = F\,(\beta_0 + \beta_E \ln(\text{Income}) + \beta_h \text{Life phase}_h + \beta_i \text{Urban}_i + \beta_j \text{Country}_j + u) \quad [1]$$

$$P(\text{expenditure on commodity } n > 0) = F\,(\beta_0 + \beta_E \ln(\text{Income}) + \beta_h \text{HHS}_h + \beta_i \text{Education}_i + \beta_1 \text{Gender} + \beta_j \text{Age}_j + \beta_k \text{Urban}_k + \beta_l \text{Country}_l + u) \quad [2]$$

where P(expenditure on commodity n > 0) is the probability of having expenditure in a specific consumption category; $F(z) = e^z/(1 + e^z)$ is the cumulative logistic distribution; income is disposable income per capita; life phase, urban, household size (HHS), education, age (in 5-year classes), and country, are class variables; gender is a dummy variable (0 = male, 1 = female), betas are regression coefficients, and *u* is an error term. Controlling for the country controls the specific country characteristics related to different product prices, production technologies, etc., and also the differences in survey data collection (for more details, see Ottelin et al., 2019).

The respective linear regression models used in the study are as follows:

$$\ln(\text{expenditure on commodity } n) = \beta_0 + \beta_E \ln(\text{Income}) + \beta_h \text{Life phase}_h + \beta_i \text{Urban}_i + \beta_j \text{Country}_j + u \quad [3]$$

$$\ln(\text{expenditure on commodity } n) = \beta_0 + \beta_E \ln(\text{Income}) + \beta_h \text{HHS}_h + \beta_i \text{Education}_i + \beta_1 \text{Gender} + \beta_j \text{Age}_j + \beta_k \text{Urban}_k + \beta_l \text{Country}_l + u) \quad [4]$$

We used STATA's survey settings in all regression analyses, including those on material footprints. Importantly this allows for using survey weights in the analyses since they are vital when large survey datasets are used (Ala-Mantila et al., 2014; Ottelin et al., 2019). These weights correct the demographic differences between the sample and the actual population. In the case of Eurostat's HBS, weights also take into account the different sample sizes of different countries, so that the actual EU averages can be analysed. The survey weights provided by the Eurostat HBS were used throughout the study. In addition, we multiplied the weights by the household size, because the unit of analysis in the study is individual consumer, not household as in the HBS.

In each analysis, we aimed for as large sample size as possible, but because of data limitations we had to exclude some countries from specific regression models. We excluded a country if its sample size for the model in question was below 50 households. In addition, we excluded countries from some models because of missing data (Table A1 in the appendix). Excluded countries are noted in the results. We also calculated the variance inflation factors (VIFs) after each regression model to check for multicollinearity (VIFs above 10 are usually considered problematic). The VIFs for the variables of interest were below three in all cases. Germany and Poland had relatively high VIFs (5 to 6) in some models, but we found this acceptable given that the focus of the analysis was not on country comparisons.

In the case of waste management, there are significant differences between countries in data quality. In some countries, waste management services are part of rentals and/or other housing related payments, which may explain the lower data coverage. In order to get meaningful regression results, we divided countries into three groups based on the share of households who have expenditure in “refuse collection” (COICOP 0442): (1) 80-100% paid for refuse collection: CZ, DK, EL, ES, HR, CY, LV, LU, SI (2) less than 80% but more than 0% payed for refuse collection: BE, BG, EE, IE, LT, HU, PL, PT, SK, FI, and (3) no data: DE, FR, IT, MT, SE, UK (the country abbreviations are provided in Table A1 in the appendix) . We studied groups 1 and 2 separately, and excluded group 3 from the waste analyses. The most relevant model for waste generation is the linear regression model for group 1, since this uses the richest data. In the case of logit models, it should be noted that there are likely to be other reasons aside from consumption habits for higher or lower likelihood of paying for waste management. For example, rentals may include waste management services.

## The degree of urbanisation and the studied EU regions

The Eurostat’s HBS includes a common variable for the degree of urbanisation, which was used here. It is based on local administrative boundaries. Areas are divided into cities (at least 500 inhabitants per $km^2$), towns and suburbs (100-499), and rural areas (<100). For the purpose of material footprint illustration (Figure 3) we divided the studied countries into Northern Europe (DK, FI), Western Europe (BE, FR, UK, IE, LU), Eastern Europe (BG, CZ, HU, EE, LV, LT, PL, SI, SK), and Southern Europe (ES, IT, EL, PT, HR, MT, CY). Sweden was excluded from most of the analyses, including Figure 3, since it didn’t have the needed “life phase” or “education” variables. Germany was excluded from all material footprint analyses due to missing data on detailed consumption categories.

## Comparison of material footprints

We conducted two separate footprint analyses. First, we compared the material footprints of different household types, and analysed whether the circular consumption habits of each household type are reflected in their footprints. Second, we examined the connection between selected circular consumption indicators and footprints. The selected indicators were the purchasing of repair and hiring services, public transport, and a vegetarian diet. To be exact, the “vegetarian” diet used here is actually lacto-ovo-pesco vegetarian diet, meaning that it excludes meat, but may include fish, eggs, and dairy products. Even this loose definition of vegetarians gives a relatively small group of people: around 3% of the whole population.

We selected indicators that don’t correlate heavily with income. Income is the main driver of expenditure, which is the main driver of material footprints, and thus either income or expenditure needs to be controlled for when the aim is to study the impact of other variables. Including an indicator that correlates strongly with income in a regression model that includes income would cause collinearity, making it impossible to interpret the results unambiguously.

We used expenditure as a control variable to compare households with similar levels of total expenditure. Thus, we avoid possible biases related to households who have underreported their consumption in the HBS. The downside is that the models don’t capture real differences in savings rates either (Ottelin, 2016).

The general regression model used in the material footprint analysis is as follows:

$$\ln(\text{Material footprint}) = \beta_0 + \beta_E \ln(\text{expenditure}) + \beta_h \text{Life phase}_h + \beta_i \text{Circular consumption indicator}_i + \beta_j \text{Country}_j + u \quad [5]$$

where material footprint is the total material footprint per capita; expenditure is total expenditure per capita; the circular consumption indicator is a selected dummy variable; and the remaining variables are the same as defined above for the equations 1-4.

Finally, we reveal potential rebound effects by using illustrations and regression analysis. As explained by Ottelin (2016), it is important to control for other variables that can affect the environmental footprints, when the aim is to illustrate and estimate the rebound effects of specific environmental actions. Thus, in order to control for income and household type in the result figures, we used middle-income working-age (25-64 y.) singles as a case group. We created country specific income groups, and the middle-income group includes the middle-income 50% of the case population. We report selected case countries that have particularly rich data regarding the tested circular consumption indicator in question. We also aimed for geographical balance. See tables A8 and A9 in the appendix for further details on the studied groups.

## Results and discussion

### Relationship between socioeconomic variables and consumption habits

Most socioeconomic groups engage in both circular- and linear consumption, but different groups adopt different circular features (see Figure 2). No clear forerunners of circular consumption were found. Regarding household type, young (16-24 y.) singles and couples show stronger circular consumption patterns than others, but they tend to consume more on tangibles and are more likely to purchase motor vehicles than older people without children. This could be because many of their goods are first-time purchases, including vehicles. At the same time, seniors (>=65 y.) consume more on repair and refurbishing services than any other household type, but they also spend more on meat products and waste management, suggesting higher waste generation. Families with children tend to consume a wide variety of products and services, but simultaneously, they get significant economies-of-scale benefits due to intra-household sharing, as highlighted by previous studies (Wier et al., 2001; Ala-Mantila et al., 2016). This is reflected by their higher likelihood of consumption in many (circular- and linear) consumption categories but lower expenditure overall.

Increasing income increases circular consumption by increasing the likelihood of consuming repair, hiring and refurbishing services, how much is spent on maintenance services, and services in general. However, the likelihood of rental living decreases with increasing income, and its connection to the level of public transport is weak. Income is also a significant driver of linear consumption, particularly motor fuels, air travel and tangibles. Surprisingly, its impact on the consumption of meat and on the likelihood of purchasing vehicles is low. Purchasing vehicles includes the purchases of second-hand vehicles here. Furthermore, increasing income increases spending on waste management services.

Increasing levels of education enhances circular consumption habits. Unlike income, it clearly increases the use of public transport. However, increasing levels of education increases driving and air travel too, which has significant environmental consequences. Gender differences are small compared to the other socioeconomic variables. Women seem to have more circular features in their consumption than men (such as using public transport, and rental and repair services), but they tend to spend slightly more on tangibles and are more likely to travel by plane.

Urbanisation is also connected to consumption habits. Previous studies find that cities may see increases in sharing due to their high concentration of households and businesses (Ala-Mantila et al., 2016; Fremstad et al., 2018). We find similar results to other studies that public transport and services in general are increased in urban regions, but also that urban residents are more likely to use repair and hiring services than rural residents. However, it is possible that it is more common for people to repair their own goods in rural areas and to lend items to neighbours for free. This type of behaviour would be in line with circularity and sustainability, but it is not captured by circular economy measurements, since neither activity is monetized. In the monetization of circular economy cities play the major role. However, our results reveal that cities also have downsides regarding the circular economy. Although a major concept of the circular economy is that leasing and hiring activities would decrease the need of ownership, city residents consume tangibles slightly more than suburban and rural residents, and their expenditure on waste management services is higher, despite the fact that some of the costs may be embedded in rentals.

| | Circular consumption | | | | | | Linear consumption | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dependent variable | Repair (d) | Refurbish (d) | Public transport (d) | Rental housing (d) | Services | Maintenance | Motor fuels (d) | Air travel (d) | Purchase of vehicles (d) | Tangibles | Meat | Waste |
| Income | 0.53 | 0.43 | 0.09 | -1.24 | 0.74 | 0.68 | 0.78 | 0.76 | 0.37 | 0.75 | 0.26 | 0.42 |
| Life phase: Singles (ref.) | | | | | | | | | | | | |
| Young (16-24 y.) | -0.11 | -0.31 | 1.09 | 1.28 | 0.26 | -0.31 | 0.49 | 0.56 | 0.90 | 0.39 | -0.32 | -0.30 |
| Couples | 0.52 | 0.74 | 0.18 | -1.03 | -0.05 | 0.05 | 1.18 | 0.49 | 0.73 | 0.09 | -0.01 | -0.44 |
| Single parents | 0.46 | 0.38 | 0.63 | -0.69 | -0.05 | -0.15 | 0.97 | 0.58 | 0.73 | 0.21 | -0.31 | -0.47 |
| Young families (<5-y. child) | 0.75 | 0.88 | 0.28 | -1.44 | -0.07 | -0.11 | 1.96 | 0.85 | 1.32 | 0.19 | -0.43 | -0.85 |
| Families | 0.97 | 1.06 | 0.81 | -1.73 | -0.06 | -0.11 | 2.01 | 0.96 | 1.31 | 0.14 | -0.13 | -0.79 |
| Senior singles (>=65 y.) | 0.31 | 0.20 | -0.43 | -0.91 | -0.12 | 0.52 | -0.91 | -0.10 | -1.10 | -0.14 | 0.10 | 0.06 |
| Senior couples (>=65 y.) | 0.80 | 0.88 | -0.37 | -1.98 | -0.12 | 0.28 | 0.74 | 0.50 | -0.10 | -0.07 | 0.12 | -0.31 |
| Deg. urb.: Rural areas (ref.) | | | | | | | | | | | | |
| Towns and suburbs | 0.16 | -0.07 | 0.21 | 0.48 | 0.04 | -0.04 | -0.04 | 0.22 | -0.13 | 0.01 | -0.04 | 0.14 |
| Cities | 0.32 | -0.22 | 0.57 | 1.10 | 0.12 | -0.12 | -0.60 | 0.35 | -0.31 | 0.04 | -0.10 | 0.04 |
| Education: Primary (ref.) | | | | | | | | | | | | |
| No formal | -0.38 | -0.02 | 0.15 | -0.27 | -0.20 | -0.17 | -0.69 | -0.36 | 0.28 | -0.22 | -0.10 | -0.10 |
| Lower secondary | 0.32 | -0.04 | 0.10 | 0.19 | 0.17 | 0.07 | 0.24 | 0.29 | 0.05 | 0.20 | -0.02 | 0.07 |
| Upper secondary | 0.41 | 0.12 | -0.02 | 0.20 | 0.23 | 0.18 | 0.56 | 0.50 | 0.05 | 0.29 | 0.00 | 0.14 |
| Post-secondary non-tertiary | 0.51 | 0.04 | 0.22 | 0.22 | 0.35 | 0.20 | 0.58 | 0.57 | 0.01 | 0.40 | -0.05 | 0.08 |
| Tertiary first stage | 0.64 | 0.16 | 0.28 | 0.35 | 0.46 | 0.23 | 0.75 | 0.82 | 0.05 | 0.48 | -0.08 | 0.17 |
| Tertiary second state | 0.58 | -0.01 | 0.53 | 0.48 | 0.48 | 0.39 | 0.37 | 0.91 | -0.08 | 0.54 | -0.13 | 0.15 |
| Not specified | 0.15 | -0.03 | -0.13 | 0.32 | 0.19 | 0.02 | 0.26 | 0.39 | -0.18 | 0.12 | -0.07 | 0.45 |
| Gender (Female) | 0.07 | -0.03 | 0.24 | 0.09 | 0.02 | 0.05 | -0.36 | 0.10 | -0.07 | 0.10 | -0.05 | -0.04 |

Figure 2. A heat matrix of regression coefficients compiled from several models (see methods). Red indicates a positive and blue a negative relationship between the tested variables (left) and studied consumption indicators (top). Indicators marked with (d) represent the likelihood to purchase, others the total expenditure in the consumption category in question. Statistically significant (p<0.05) results are in bold text. Detailed regression results with standard errors and p-values are provided in Tables A2-A7 in the appendix.

## Material footprints

The material footprints of households are mainly driven by income and household size (Table 2). Families with children, and young adults (16-24 y.) have the lowest material footprints per capita (Figure 3 and Table 2). The lowest material footprint, 3.4 t per capita, is found among young families living in Eastern Europe (young families are those with one or more <5-year-old children). Singles of working-age (25-64 y.) have the highest material footprints, varying from 8.5 t per capita in Eastern Europe to 11.0 t in Southern Europe. Singles seem to have relatively higher material footprints (compared to other household types) in Eastern and Southern Europe than Northern and Western Europe. However, there are overall fewer singles in these regions, especially among under 30-year-olds, and those who are single, have significantly higher income than other household types, which explains the high material footprints. In Northern and Western Europe, low income students concentrate in the group of singles, levelling the income differences.

The composition of consumer material footprints is quite similar across Europe: food plays a major role, followed by tangibles, housing energy, and private transport in most cases. Differences are larger in Eastern Europe, where housing energy causes almost half of households' material footprints due to a heavy reliance on coal energy. However, this is compensated for by lower material footprints in other sectors (due to lower income and consumption compared to other regions). In Northern Europe, rentals cause a larger material footprint than elsewhere, probably because heating energy is usually included in rental agreements. In Southern Europe, the role of private transport (including vehicle purchase, maintenance and motor fuels) seems to be particularly high. This is due to a higher sectoral material intensity rather than higher consumption compared to other European regions. Possible reasons for higher material intensity are lower prices and/or less efficient production chains.

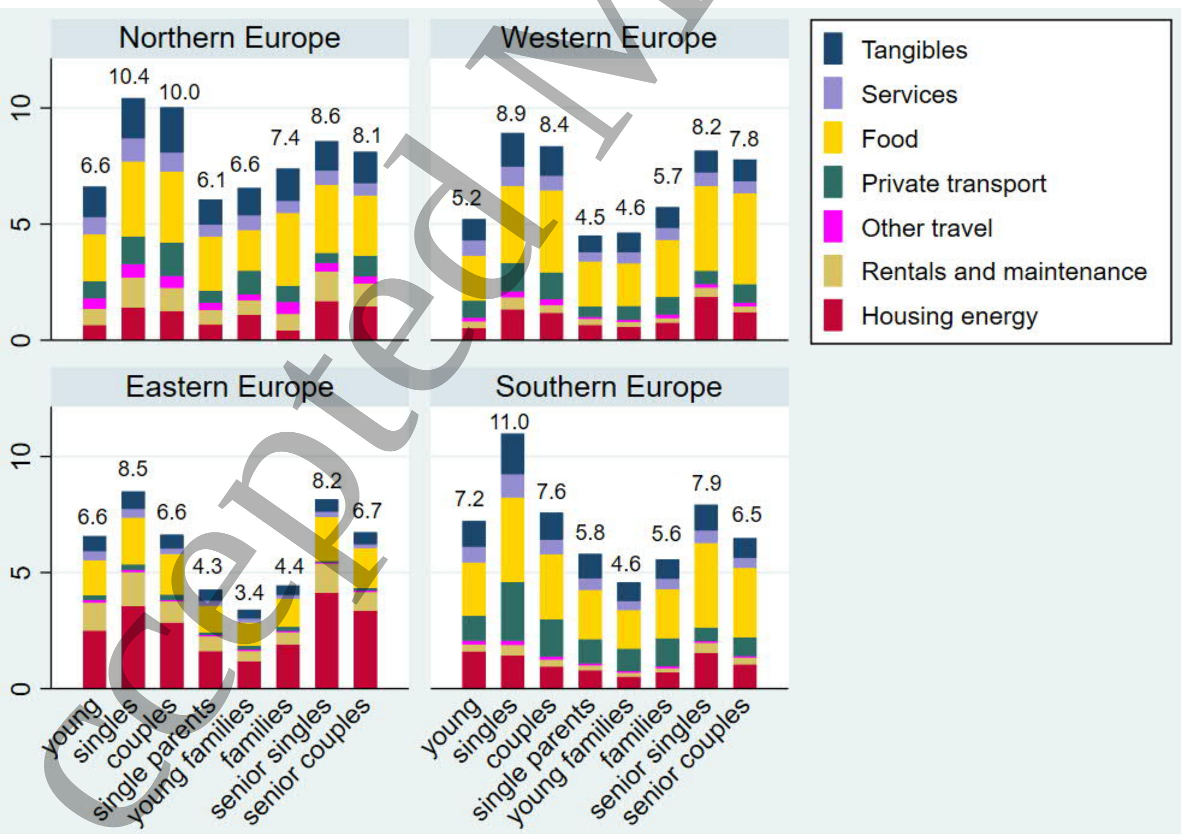


Figure 3. Material footprints of different household types across Europe (t per capita)

Although material footprints are clearly much more dependent on income and household size than individual consumption choices, some interesting observations can be made, see Figure 3. First, although young adults and families with children generally spend more on tangibles than other households when income is controlled (Figure 2), this materially intensive consumption habit does not lead to higher material footprints overall. Similarly, although working-age singles generally spend more on services than other households, this does not lead to lower material footprints overall. When young adults and seniors are compared, the seniors' higher consumption of repair and hiring services is not well reflected in their material footprints of tangibles or services, but their higher consumption of meat products is clearly reflected in their higher material footprints of food. In addition, the high likelihood among young adults, single parents, and families to use public transport services appears to correlate with lower material footprints, particularly from private transport. The findings suggest that the impact of circular consumption habits on resource savings is not straightforward, and there may be rebound effects, as we will next examine more closely.

Table 2. Regression coefficients of life phase and the degree of urbanisation indicating their impact on consumer material footprints

| Dependent variable: ln(Material footprint per capita) | Coef. | Std. Err. | P>\|t\| |
|---|---|---|---|
| ln(expenditure per capita) | 0.51 | 0.01 | 0.00 |
| Life phase: Singles (ref.) | | | |
| Young (16-24 y.) | -0.06 | 0.03 | 0.036 |
| Couples | -0.03 | 0.01 | 0.000 |
| Single parents | -0.20 | 0.02 | 0.000 |
| Young families (<5-y. child) | -0.29 | 0.01 | 0.000 |
| Families | -0.19 | 0.01 | 0.000 |
| Senior singles (>=65 y.) | *-0.01* | *0.01* | *0.195* |
| Senior couples (>=65 y.) | -0.05 | 0.01 | 0.000 |
| Deg. urb.: Rural areas (ref.) | | | |
| Towns and suburbs | -0.02 | 0.01 | 0.008 |
| Cities | -0.04 | 0.01 | 0.000 |
| Country (class variable) | | controlled | |
| R2 | 0.48 | | |
| Excluded countries | | DE, IT, SE | |

Non-significant results (p>0.05) in cursive

In terms of the connections between the studied circular consumption indicators and material footprints, the use of repair and hiring services does not imply a lower consumer material footprint (Figure 4a and Table 3). Although this is counter-intuitive, repair and hiring correlates with higher goods ownership and service use in general, which increases material footprints (Figure 4a). On average, consumers who use repair and hiring services have a 2% higher material footprint than consumers who don't when expenditure is controlled (Table 3). This may be because of a rebound related to monetary savings from using repair and hiring services. On the other hand, it is possible that consumers who buy more products also need more repairing services. Since we use cross-sectional analysis here, the causal direction remains unclear. In any case, the result suggests that repair and hiring services are currently not substitutes for purchasing new products, at least not in large scale, which poses a challenge for circular economy.

The use of public transport decreases consumer material footprints by 4% on average (Table 3), mainly due to reduced private vehicle ownership and use (Figure 4b). However, public transportation is generally much cheaper than owning and using private vehicles, and we find related rebounds. In Spain, Finland and France, consumers who use public transport, have a higher consumption and material footprint of services (Figure 4b). This probably relates to urban lifestyles – public transport services are mainly available in urban areas, where the supply of other services is also higher than in suburban and rural areas. Similarly, the consumption of "other travel", which includes public transport and holiday travel (transportation and miscellaneous consumption abroad), is naturally higher among consumers who use public transport. This is particularly true in Finland, where this offsets a large share of the benefits from decreasing private driving (Figure 4b). Curiously, in the Czech Republic, the decreasing material footprint of transportation is offset by the increasing material footprint of housing energy (Figure 4b), whereas in Spain, Finland and France, the material footprint from housing related consumption is lower among consumers who use public transport than among those who don't. The living space per capita is generally smaller in urban areas, but in the Czech Republic, the expenditure on gas, heat and electricity is higher among consumers who use public transport than those who don't, even though the income level is practically the same (Table A9 in the appendix). Previously, Buhl et al. (2019) have found that the material footprint of housing correlates negatively with vacations in Germany. They also found that environmentally conscious consumers have in general lower material footprints, except for vacations. These findings may also be related to the urban lifestyles. In sum, increasing use of public transportation can reduce material footprints, but the related rebounds can be significant, depending on the country.

Among the tested consumption habits, a vegetarian diet is most clearly connected with a lower material footprint (Figure 4c, Table 3). Laakso and Lettenmeier (2016) made similar findings related to reduced meat consumption. Consumers with a vegetarian diet have on average 64% lower material footprint of food consumption, and 23% lower total material footprint than their counterparts (Table 3). The difference is also clear in the selected case countries in Figure 4c. There appear to be no significant rebound effects, potentially because a vegetarian diet may not reduce the overall costs of diets. However, in Cyprus and Spain, vegetarian consumers have a slightly higher material footprint of services than non-vegetarian consumers. This is mainly because of higher use of restaurant services. One possible explanation is that higher education reduces meat consumption (Figure 2) and is also related to higher use of restaurant services.

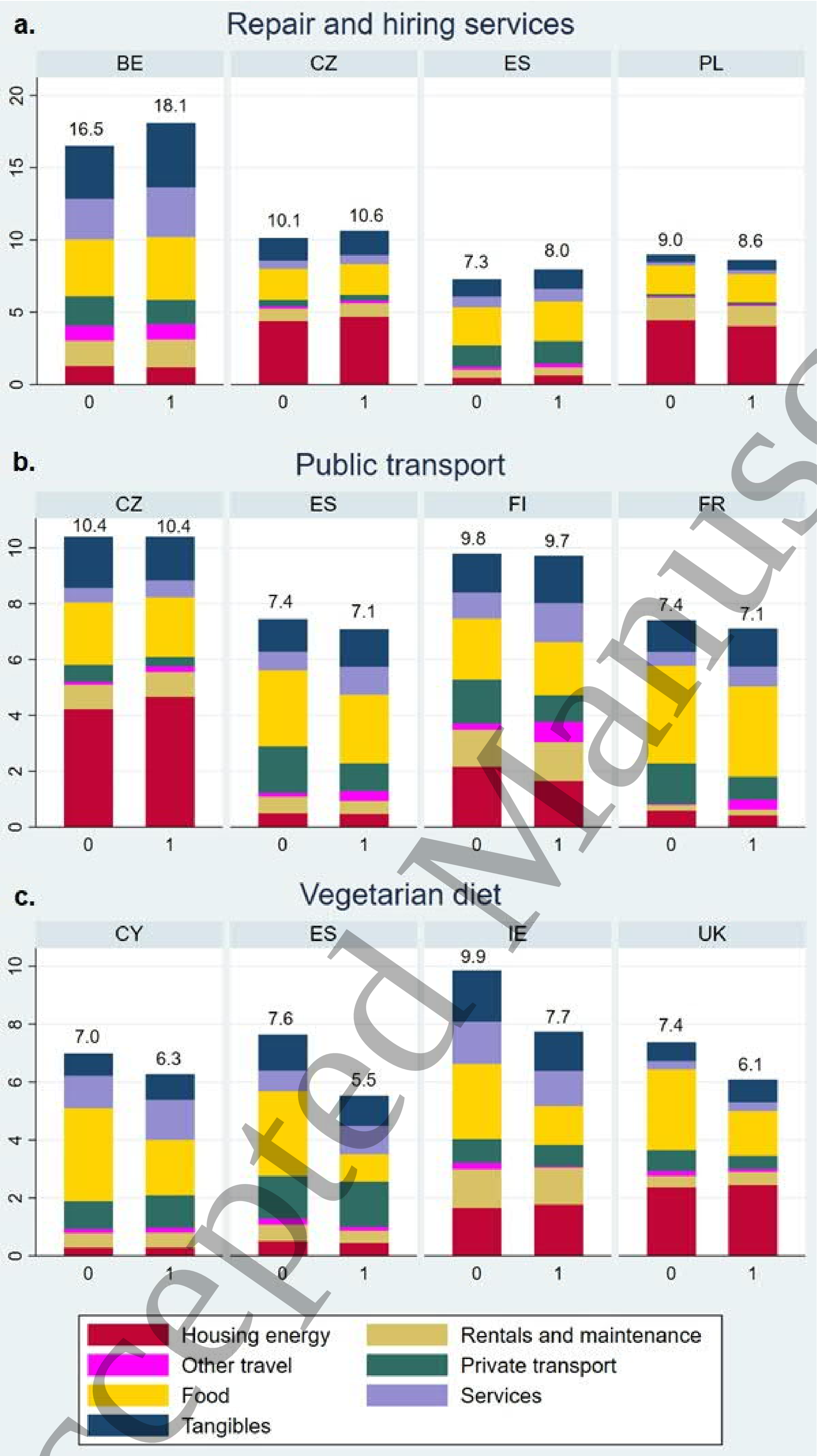


Figure 4. The connection of circular consumption habits to the material footprints of working-age (25-64 y.) middle-income singles in various European countries (t per capita). BE = Belgium, CY = Cyprus, CZ = Czech Republic, ES = Spain, FI = Finland, FR = France, IE = Ireland, PL = Poland, UK = United Kingdom

Table 3. The regression coefficients of the studied circular consumption habits indicating their impact on total consumer material footprints

| Dependent variable: ln(Material footprint per capita) | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| |
|---|---|---|---|---|---|---|---|---|---|
| ln(expenditure per capita) | 0.88 | 0.00 | 0.00 | 0.88 | 0.00 | 0.000 | 0.83 | 0.00 | 0.000 |
| Life phase: Singles (ref.) | | | | | | | | | |
| Young (16-24 y.) | -0.19 | 0.02 | 0.000 | -0.18 | 0.02 | 0.000 | -0.18 | 0.02 | 0.000 |
| Couples | 0.09 | 0.01 | 0.000 | 0.10 | 0.01 | 0.000 | 0.02 | 0.01 | 0.000 |
| Single parents | -0.03 | 0.01 | 0.001 | *-0.02* | *0.01* | *0.102* | -0.12 | 0.01 | 0.000 |
| Young families (<5 y. child) | 0.01 | 0.01 | 0.189 | 0.03 | 0.01 | 0.000 | -0.05 | 0.01 | 0.000 |
| Families | 0.07 | 0.01 | 0.000 | 0.09 | 0.01 | 0.000 | *-0.01* | *0.01* | *0.392* |
| Senior singles (>=65 y.) | 0.06 | 0.01 | 0.000 | 0.05 | 0.01 | 0.000 | 0.02 | 0.01 | 0.006 |
| Senior couples (>=65 y.) | 0.15 | 0.01 | 0.000 | 0.16 | 0.01 | 0.000 | 0.06 | 0.01 | 0.000 |
| Repair and hiring services (dummy) | 0.02 | 0.00 | 0.000 | - | | | - | | |
| Public transport (dummy) | - | | | -0.04 | 0.00 | 0.000 | - | | |
| Vegetarian diet (dummy) | - | | | - | | | -0.26 | 0.01 | 0.000 |
| Country (class variable) | | controlled | | | controlled | | | controlled | |
| R2 | 0.78 | | | 0.78 | | | 0.82 | | |
| Excluded countries | | DE, PL | | | DE, PL | | | DE, PL, FR, PT | |

Non-significant results (p>0.05) in cursive

## Limitations of the study and suggestions for future research

The study has three main sources of uncertainty. First, the circular- and linear consumption indicators used here were chosen with a process that involved subjective decisions, and other researchers may have ended up with a different set of indicators. The used data caused limitations related to this. The Eurostat HBS includes limited information related to the environmental aspects of consumption. More detailed data on the quality of purchasers (longevity of products, green product labels, second-hand products etc.) and the recycling habits of consumers would be needed for a deeper analysis on the impacts of circular consumption behaviour. In addition, studies on non-monetized sharing and collaboration are called for (e.g. sharing among neighbours), since expenditure studies cannot capture this sort of behaviour. Second, the chosen environmental indicator, material footprint, has its inherent limitations (Fang and Heijungs, 2014; Steinmann et al., 2017). It sums up all materials regardless of the place of origin or type of material. In reality, the environmental impacts of raw material extraction vary between materials and locations. This is a very important issue for circular economy measurement: the circularity of some materials may be more important than the circularity of others with respect to environmental sustainability. The third main limitation is that the material footprint of construction of buildings and infrastructure is largely excluded due to data limitations (see the method section for details). In their recent study, Södersten et al. (2020) highlight that including capital load in material footprints increases footprints significantly, particularly in real estate and other service sectors. Future studies could address the presented limitations with improved data collection and material footprint models. In addition, it would be good to collect longitudinal expenditure data in order to study causal relationships more rigorously.

# Conclusions and policy implications

Here we examined what types of households exhibit circular consumption habits, and how circular consumption choices are connected to material footprints. We found no clear leaders in circular consumption. Instead, different types of households adopt different features of circular consumption, depending on age, life phase, gender, education etc. Furthermore, circular consumption choices don't necessarily lead to a lower material footprint. The use of repair and hiring services doesn't seem to decrease material footprints, and the use of public transport has significant rebounds in some of the studied countries. Among the studied circular and ecological consumption choices, a vegetarian diet has the clearest connection to lower material footprints. Overall, the results highlight that rebounds due to shifting consumption have a high potential to jeopardize the expected benefits of circular consumption.

Although consumption choices can potentially have a strong impact on environmental footprints, their impact in practice is often limited. Most consumers have no knowledge or understanding of rebound effects, and thus they may have high footprints despite being environmentally conscious in some areas of life (Ottelin et al., 2017; Buhl et al., 2019). Furthermore, even in the best case, consumers can only impact on their own purchases – not the economic flows after the purchase. A recent study by Greenford et al. (2020) reveals that if the environmental impacts of labour (meaning the consumption of workers) are taken into account, there is actually little difference, whether we consume products or services.

Previous studies have highlighted potential rebounds in the circular economy from a production perspective (Zink & Geyer, 2017; Figge & Thorpe, 2019). Here, we focused on household level rebounds related to constant household budgets. It should be noted that the circular economy fits within the green growth paradigm in the sense that it doesn't question the aim of continuous growth. Thus, in a circular economy, growing household budgets would be expected. As Zink and Geyer (2017) highlight, circular economy may actually lead to increasing overall production (and consumption), instead of substituting virgin materials with circulating materials. In order to avoid such a scenario, the use of virgin materials needs to be restricted, in addition to creating incentives to use secondary and renewable materials. For instance, the taxation of non-renewable resources should be increased, and taxation of renewable resources and labour should be decreased (Ellen MacArthur Foundation, 2013; Ghisellini et al., 2016; Ottelin et al., 2018). Fossil fuels should be phased-out systematically to avoid leakage effects (Le Quéré et al., 2019). Other, non-monetary policies, such as green product labels and nudging, can also be used to support eco-efficiency and eco-design, and guide consumer choices (Ghisellini et al., 2016; Lehner et al., 2016; Geissdoerfer et al., 2017). However, these should be seen as a complement to regulation and economic policy instruments, not as alternatives.

It is often asked how rebound effects could be mitigated. However, this is not necessarily a meaningful aim. From the consumer perspective, a better aim would be to have equally low material (or any environmental impact) intensity (kg/€) for all products and services. In such a scenario, rebounds would always be 100%, and consumption choices would not make any difference from the environmental perspective. Although such an aim is practically impossible to achieve, it could be approached by the above-mentioned economic policies, and phase-out of environmentally most harmful economic activities.

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## Appendix

Table A1. Country abbreviations, sample sizes, and relevant data limitations

| Country | Abbr. | Sample size (households) | Data limitations | | | |
|---|---|---|---|---|---|---|
| | | | Income | Life phase | Education | Detailed COICOP categories |
| Belgium | BE | 7 177 | | | | |
| Bulgaria | BG | 2 982 | | | | |
| Czech Republic | CZ | 2 932 | | | | |
| Denmark | DK | 2 484 | | | x | |
| Germany* | DE | 53 996 | | | | x |
| Estonia | EE | 3 632 | | | | |
| Ireland | IE | 5 891 | | | | |
| Greece | EL | 3 512 | | | | |
| Spain | ES | 22 203 | | | | |
| France | FR | 15 797 | | | | |
| Croatia | HR | 3 461 | | | | |
| Italy** | IT | 22 246 | x | | | |
| Cyprus | CY | 2 707 | | | | |
| Latvia | LV | 3 798 | | | | |
| Lithuania | LT | 6 103 | | | | |
| Luxembourg | LU | 3 492 | | | | |
| Hungary | HU | 9 937 | | | | |
| Malta | MT | 3 732 | | | | |
| Poland | PL | 37 412 | | | | |
| Portugal | PT | 9 489 | | | | |
| Slovenia | SI | 3 924 | | | x | |
| Slovakia | SK | 6 143 | | | | |
| Finland | FI | 3 551 | | | x | |
| Sweden*** | SE | 2 047 | | x | x | |
| United Kingdom | UK | 5 263 | | | x | |

* Material footprints were not calculated for German households, due to the lack of detailed expenditure data
** Italy is excluded from all regression models that include income
*** Sweden is excluded from all regression models that include life phase or education

Table A2. The regression coefficients of life phase and the degree of urbanisation indicating their impact on circular consumption indicators

| Dependent variable | Repair (d) | | | Refurbish (d) | | | Public transport (d) | | | Rental housing (d) | | | ln(Services) | | | ln(Maintenance) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| |
| ln(income per capita) | 0.53 | 0.02 | 0.000 | 0.43 | 0.02 | 0.000 | 0.09 | 0.02 | 0.000 | -1.24 | 0.03 | 0.000 | 0.74 | 0.01 | 0.000 | 0.68 | 0.02 | 0.000 |
| Life phase: Singles (ref.) | | | | | | | | | | | | | | | | | | |
| Young (16-24 y.) | *-0.11* | *0.08* | *0.181* | -0.31 | 0.11 | 0.005 | 1.09 | 0.09 | 0.000 | 1.28 | 0.11 | 0.000 | 0.26 | 0.03 | 0.000 | -0.31 | 0.06 | 0.000 |
| Couples | 0.52 | 0.03 | 0.000 | 0.74 | 0.03 | 0.000 | 0.18 | 0.04 | 0.000 | -1.03 | 0.03 | 0.000 | -0.05 | 0.01 | 0.000 | 0.05 | 0.02 | 0.021 |
| Single parents | 0.46 | 0.05 | 0.000 | 0.38 | 0.06 | 0.000 | 0.63 | 0.06 | 0.000 | -0.69 | 0.05 | 0.000 | -0.05 | 0.02 | 0.005 | -0.15 | 0.04 | 0.000 |
| Young families (<5-y. child) | 0.75 | 0.04 | 0.000 | 0.88 | 0.04 | 0.000 | 0.28 | 0.04 | 0.000 | -1.44 | 0.04 | 0.000 | -0.07 | 0.01 | 0.000 | -0.11 | 0.02 | 0.000 |
| Families | 0.97 | 0.03 | 0.000 | 1.06 | 0.03 | 0.000 | 0.81 | 0.04 | 0.000 | -1.73 | 0.03 | 0.000 | -0.06 | 0.01 | 0.000 | -0.11 | 0.02 | 0.000 |
| Senior singles (>=65 y.) | 0.31 | 0.04 | 0.000 | 0.20 | 0.04 | 0.000 | -0.43 | 0.05 | 0.000 | -0.91 | 0.03 | 0.000 | -0.12 | 0.01 | 0.000 | 0.52 | 0.02 | 0.000 |
| Senior couples (>=65 y.) | 0.80 | 0.03 | 0.000 | 0.88 | 0.04 | 0.000 | -0.37 | 0.04 | 0.000 | -1.98 | 0.04 | 0.000 | -0.12 | 0.01 | 0.000 | 0.28 | 0.02 | 0.000 |
| Deg. urb.: Rural areas (ref.) | | | | | | | | | | | | | | | | | | |
| Towns and suburbs | 0.16 | 0.03 | 0.000 | -0.07 | 0.03 | 0.004 | 0.21 | 0.03 | 0.000 | 0.48 | 0.03 | 0.000 | 0.04 | 0.01 | 0.000 | -0.04 | 0.02 | 0.004 |
| Cities | 0.32 | 0.03 | 0.000 | -0.22 | 0.02 | 0.000 | 0.57 | 0.02 | 0.000 | 1.10 | 0.03 | 0.000 | 0.12 | 0.01 | 0.000 | -0.12 | 0.01 | 0.000 |
| Country (class variable) | | controlled | | | controlled | | | controlled | | | controlled | | | controlled | | | controlled | |
| R2 | n.a. | | | n.a. | | | n.a. | | | n.a. | | | 0.64 | | | 0.20 | | |
| Excluded countries | | | | | | | | DE | | | BG | | | | | | | |

Non-significant results (p>0.05) in cursive

Table A3. The regression coefficients of life phase and the degree of urbanisation indicating their impact on linear consumption indicators

| Dependent variable | Motor fuels (d) | | | Air travel (d) | | | Purchase of vehicles (d) | | | ln(Tangibles) | | | ln(Meat) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| |
| ln(income per capita) | 0.78 | 0.02 | 0.000 | 0.76 | 0.02 | 0.000 | 0.37 | 0.03 | 0.000 | 0.75 | 0.01 | 0.000 | 0.26 | 0.01 | 0.000 |
| Life phase: Singles (ref.) | | | | | | | | | | | | | | | |
| Young (16-24 y.) | 0.49 | 0.08 | 0.000 | 0.56 | 0.10 | 0.000 | 0.90 | 0.13 | 0.000 | 0.39 | 0.04 | 0.000 | -0.32 | 0.04 | 0.000 |
| Couples | 1.18 | 0.03 | 0.000 | 0.49 | 0.03 | 0.000 | 0.73 | 0.05 | 0.000 | 0.09 | 0.01 | 0.000 | *-0.01* | *0.02* | *0.714* |
| Single parents | 0.97 | 0.05 | 0.000 | 0.58 | 0.06 | 0.000 | 0.73 | 0.09 | 0.000 | 0.21 | 0.02 | 0.000 | -0.31 | 0.02 | 0.000 |
| Young families (<5-y. child) | 1.96 | 0.04 | 0.000 | 0.85 | 0.04 | 0.000 | 1.32 | 0.06 | 0.000 | 0.19 | 0.02 | 0.000 | -0.43 | 0.02 | 0.000 |
| Families | 2.01 | 0.03 | 0.000 | 0.96 | 0.03 | 0.000 | 1.31 | 0.05 | 0.000 | 0.14 | 0.02 | 0.000 | -0.13 | 0.01 | 0.000 |
| Senior singles (>=65 y.) | -0.91 | 0.03 | 0.000 | -0.10 | 0.04 | 0.024 | -1.10 | 0.09 | 0.000 | -0.14 | 0.02 | 0.000 | 0.10 | 0.02 | 0.000 |
| Senior couples (>=65 y.) | 0.74 | 0.03 | 0.000 | 0.50 | 0.04 | 0.000 | *-0.10* | *0.07* | *0.191* | -0.07 | 0.02 | 0.000 | 0.12 | 0.02 | 0.000 |
| Deg. urb.: Rural areas (ref.) | | | | | | | | | | | | | | | |
| Towns and suburbs | *-0.04* | *0.03* | *0.136* | 0.22 | 0.03 | 0.000 | -0.13 | 0.04 | 0.001 | *0.01* | *0.01* | *0.246* | -0.04 | 0.01 | 0.001 |
| Cities | -0.60 | 0.02 | 0.000 | 0.35 | 0.03 | 0.000 | -0.31 | 0.03 | 0.000 | 0.04 | 0.01 | 0.000 | -0.10 | 0.01 | 0.000 |
| Country (class variable) | | controlled | | | controlled | | | controlled | | | controlled | | | controlled | |
| R2 | n.a. | | | n.a. | | | n.a. | | | 0.44 | | | 0.22 | | |
| Excluded countries | | | | | | | | BG, LT, SK | | | | | | DE | |

Non-significant results (p>0.05) in cursive

Table A4. The regression coefficients of life phase and the degree of urbanisation indicating their impact on usage of waste management services

| | 80-100% payed for refuse collection | | | | | | 10%-80% payed for refuse collection | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Countries | CZ, ES, HR, CY, LV, SI | | | CZ, DK, EL, ES, HR, CY, LV, LU, SI | | | BE, BG, EE, IE, LT, HU, PL, PT, SK, FI | | | | | |
| Dependent variable | Waste (d) | | | ln(Waste) | | | Waste (d) | | | ln(Waste) | | |
| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| |
| ln(income per capita) | 0.53 | 0.05 | 0.000 | 0.42 | 0.02 | 0.000 | 0.55 | 0.02 | 0.000 | 0.22 | 0.01 | 0.000 |
| Life phase: Singles (ref.) | | | | | | | | | | | | |
| Young (16-24 y.) | -0.73 | 0.27 | 0.006 | -0.30 | 0.05 | 0.000 | -0.25 | 0.08 | 0.001 | -0.35 | 0.03 | 0.000 |
| Couples | 0.62 | 0.09 | 0.000 | -0.44 | 0.02 | 0.000 | 0.51 | 0.03 | 0.000 | -0.35 | 0.01 | 0.000 |
| Single parents | 0.70 | 0.14 | 0.000 | -0.47 | 0.04 | 0.000 | 0.60 | 0.06 | 0.000 | -0.51 | 0.02 | 0.000 |
| Young families (<5-y. child) | 0.93 | 0.10 | 0.000 | -0.85 | 0.03 | 0.000 | 0.80 | 0.04 | 0.000 | -0.84 | 0.02 | 0.000 |
| Families | 1.21 | 0.09 | 0.000 | -0.79 | 0.02 | 0.000 | 0.63 | 0.03 | 0.000 | -0.71 | 0.01 | 0.000 |
| Senior singles (>=65 y.) | 0.61 | 0.10 | 0.000 | 0.06 | 0.02 | 0.008 | 0.17 | 0.04 | 0.000 | -0.03 | 0.02 | 0.046 |
| Senior couples (>=65 y.) | 1.12 | 0.11 | 0.000 | -0.31 | 0.02 | 0.000 | 0.61 | 0.05 | 0.000 | -0.37 | 0.02 | 0.000 |
| Deg. urb.: Rural areas (ref.) | | | | | | | | | | | | |
| Towns and suburbs | -0.28 | 0.07 | 0.000 | 0.14 | 0.02 | 0.000 | *-0.05* | *0.03* | *0.087* | 0.13 | 0.01 | 0.000 |
| Cities | -0.85 | 0.05 | 0.000 | 0.04 | 0.02 | 0.010 | 0.45 | 0.02 | 0.000 | 0.11 | 0.01 | 0.000 |
| Country (class variable) | controlled | | | controlled | | | controlled | | | controlled | | |
| R2 | n.a. | | | 0.35 | | | n.a. | | | 0.40 | | |

Non-significant results (p>0.05) in cursive

Table A5. The regression coefficients of education and gender indicating their impact on circular consumption indicators

| Dependent variable | Repair (d) | | | Refurbish (d) | | | Public transport (d) | | | Rental housing (d) | | | ln(Services) | | | ln(Maintenance) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| |
| ln(income per capita) | 0.45 | 0.02 | 0.000 | 0.38 | 0.02 | 0.000 | *-0.03* | *0.02* | *0.083* | -1.45 | 0.03 | 0.000 | 0.61 | 0.02 | 0.000 | 0.59 | 0.02 | 0.000 |
| Household size: 1 person (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | 0.49 | 0.02 | 0.000 | 0.69 | 0.02 | 0.000 | 0.23 | 0.03 | 0.000 | -0.93 | 0.02 | 0.000 | -0.07 | 0.01 | 0.000 | -0.09 | 0.02 | 0.000 |
| 3 | 0.79 | 0.03 | 0.000 | 0.94 | 0.03 | 0.000 | 0.49 | 0.03 | 0.000 | -1.44 | 0.03 | 0.000 | -0.09 | 0.01 | 0.000 | -0.13 | 0.02 | 0.000 |
| >=4 | 1.11 | 0.03 | 0.000 | 1.19 | 0.03 | 0.000 | 0.76 | 0.03 | 0.000 | -1.94 | 0.04 | 0.000 | -0.15 | 0.01 | 0.000 | -0.17 | 0.02 | 0.000 |
| Education: Primary (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| No formal | -0.38 | 0.09 | 0.000 | *-0.02* | *0.06* | *0.700* | 0.15 | 0.06 | 0.010 | -0.27 | 0.08 | 0.001 | -0.20 | 0.02 | 0.000 | -0.17 | 0.04 | 0.000 |
| Lower secondary | 0.32 | 0.04 | 0.000 | *-0.04* | *0.03* | *0.145* | 0.10 | 0.03 | 0.003 | 0.19 | 0.04 | 0.000 | 0.17 | 0.01 | 0.000 | 0.07 | 0.02 | 0.001 |
| Upper secondary | 0.41 | 0.04 | 0.000 | 0.12 | 0.03 | 0.000 | *-0.02* | *0.03* | *0.605* | 0.20 | 0.04 | 0.000 | 0.23 | 0.01 | 0.000 | 0.18 | 0.02 | 0.000 |
| Post-secondary non-tertiary | 0.51 | 0.04 | 0.000 | *0.04* | *0.04* | *0.222* | 0.22 | 0.04 | 0.000 | 0.22 | 0.04 | 0.000 | 0.35 | 0.01 | 0.000 | 0.20 | 0.03 | 0.000 |
| Tertiary first stage | 0.64 | 0.04 | 0.000 | 0.16 | 0.03 | 0.000 | 0.28 | 0.04 | 0.000 | 0.35 | 0.04 | 0.000 | 0.46 | 0.01 | 0.000 | 0.23 | 0.02 | 0.000 |
| Tertiary second state | 0.58 | 0.04 | 0.000 | *-0.01* | *0.04* | *0.875* | 0.53 | 0.04 | 0.000 | 0.48 | 0.05 | 0.000 | 0.48 | 0.01 | 0.000 | 0.39 | 0.03 | 0.000 |
| Not specified | *0.15* | *0.13* | *0.249* | *-0.03* | *0.07* | *0.706* | -0.13 | 0.06 | 0.024 | 0.32 | 0.06 | 0.000 | 0.19 | 0.01 | 0.000 | 0.02 | 0.04 | 0.726 |
| Gender (Female) | 0.07 | 0.02 | 0.000 | *-0.03* | *0.02* | *0.116* | 0.24 | 0.02 | 0.000 | 0.09 | 0.02 | 0.000 | 0.02 | 0.01 | 0.002 | 0.05 | 0.01 | 0.000 |
| Age: 20-24 (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0-19 | *0.08* | *0.30* | *0.790* | *-0.25* | *0.23* | *0.276* | 0.55 | 0.20 | 0.007 | -0.90 | 0.29 | 0.002 | 0.15 | 0.07 | 0.028 | 0.04 | 0.13 | 0.747 |
| 25-29 | *0.04* | *0.08* | *0.585* | 0.19 | 0.07 | 0.008 | -0.62 | 0.08 | 0.000 | -0.25 | 0.09 | 0.004 | -0.08 | 0.02 | 0.000 | 0.09 | 0.05 | 0.055 |
| 30-34 | *0.11* | *0.08* | *0.163* | 0.28 | 0.07 | 0.000 | -0.89 | 0.07 | 0.000 | -0.78 | 0.08 | 0.000 | -0.08 | 0.02 | 0.000 | 0.20 | 0.04 | 0.000 |
| 35-39 | *0.12* | *0.07* | *0.107* | 0.29 | 0.07 | 0.000 | -0.93 | 0.07 | 0.000 | -1.20 | 0.08 | 0.000 | -0.10 | 0.02 | 0.000 | 0.26 | 0.04 | 0.000 |
| 40-44 | 0.18 | 0.07 | 0.011 | 0.38 | 0.07 | 0.000 | -0.62 | 0.07 | 0.000 | -1.39 | 0.08 | 0.000 | -0.08 | 0.02 | 0.000 | 0.28 | 0.04 | 0.000 |
| 45-49 | 0.35 | 0.07 | 0.000 | 0.38 | 0.07 | 0.000 | -0.47 | 0.07 | 0.000 | -1.36 | 0.08 | 0.000 | -0.09 | 0.02 | 0.000 | 0.29 | 0.04 | 0.000 |
| 50-54 | 0.45 | 0.07 | 0.000 | 0.46 | 0.07 | 0.000 | -0.44 | 0.07 | 0.000 | -1.47 | 0.08 | 0.000 | -0.08 | 0.02 | 0.000 | 0.39 | 0.04 | 0.000 |
| 55-59 | 0.56 | 0.07 | 0.000 | 0.46 | 0.07 | 0.000 | -0.57 | 0.07 | 0.000 | -1.72 | 0.08 | 0.000 | -0.09 | 0.02 | 0.000 | 0.44 | 0.04 | 0.000 |
| 60-64 | 0.67 | 0.07 | 0.000 | 0.61 | 0.07 | 0.000 | -0.63 | 0.07 | 0.000 | -1.96 | 0.08 | 0.000 | -0.10 | 0.02 | 0.000 | 0.51 | 0.04 | 0.000 |
| 65-69 | 0.74 | 0.07 | 0.000 | 0.65 | 0.07 | 0.000 | -0.74 | 0.07 | 0.000 | -2.15 | 0.08 | 0.000 | -0.09 | 0.02 | 0.000 | 0.59 | 0.04 | 0.000 |
| 70-74 | 0.81 | 0.07 | 0.000 | 0.59 | 0.07 | 0.000 | -0.84 | 0.07 | 0.000 | -2.23 | 0.08 | 0.000 | -0.07 | 0.02 | 0.000 | 0.60 | 0.04 | 0.000 |
| >=75 | 0.66 | 0.07 | 0.000 | 0.39 | 0.07 | 0.000 | -1.04 | 0.07 | 0.000 | -2.33 | 0.08 | 0.000 | -0.13 | 0.02 | 0.000 | 0.80 | 0.04 | 0.000 |
| Deg. urb.: Rural areas (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Towns and suburbs | 0.13 | 0.02 | 0.000 | -0.06 | 0.02 | 0.003 | 0.17 | 0.03 | 0.000 | 0.53 | 0.03 | 0.000 | 0.04 | 0.01 | 0.000 | -0.08 | 0.01 | 0.000 |
| Cities | 0.30 | 0.02 | 0.000 | -0.23 | 0.02 | 0.000 | 0.61 | 0.02 | 0.000 | 1.22 | 0.03 | 0.000 | 0.11 | 0.01 | 0.000 | -0.14 | 0.01 | 0.000 |
| Country (class variable) | controlled | | | controlled | | | controlled | | | controlled | | | controlled | | | controlled | | |
| $R^2$ | n.a. | | | n.a. | | | n.a. | | | n.a. | | | 0.64 | | | 0.20 | | |
| Excluded countries | DK, SI, SE, FI, UK | | | DK, SI, SE, FI, UK | | | DK, SI, SE, FI, UK, DE | | | DK, SI, SE, FI, UK, BG | | | DK, SI, SE, FI, UK | | | DK, SI, SE, FI, UK | | |

Non-significant results (p>0.05) in cursive

Table A6. The regression coefficients of education and gender indicating their impact on linear consumption indicators

| Dependent variable | Motor fuels (d) | | | Air travel (d) | | | Purchase of vehicles (d) | | | ln(Tangibles) | | | ln(Meat) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| |
| ln(income per capita) | 0.84 | 0.02 | 0.000 | 0.76 | 0.02 | 0.000 | 0.52 | 0.03 | 0.000 | 0.66 | 0.02 | 0.000 | 0.25 | 0.01 | 0.000 |
| Household size: 1 person (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | 1.26 | 0.02 | 0.000 | 0.50 | 0.02 | 0.000 | 0.87 | 0.05 | 0.000 | 0.08 | 0.01 | 0.000 | -0.04 | 0.01 | 0.000 |
| 3 | 1.80 | 0.03 | 0.000 | 0.76 | 0.03 | 0.000 | 1.35 | 0.05 | 0.000 | 0.11 | 0.01 | 0.000 | -0.13 | 0.01 | 0.000 |
| >=4 | 2.25 | 0.04 | 0.000 | 1.24 | 0.03 | 0.000 | 1.72 | 0.06 | 0.000 | 0.12 | 0.02 | 0.000 | -0.24 | 0.01 | 0.000 |
| Education: Primary (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| No formal | -0.69 | 0.06 | 0.000 | -0.36 | 0.09 | 0.000 | 0.28 | 0.11 | 0.011 | -0.22 | 0.03 | 0.000 | -0.10 | 0.02 | 0.000 |
| Lower secondary | 0.24 | 0.03 | 0.000 | 0.29 | 0.04 | 0.000 | *0.05* | *0.05* | *0.359* | 0.20 | 0.02 | 0.000 | *-0.02* | *0.01* | *0.241* |
| Upper secondary | 0.56 | 0.03 | 0.000 | 0.50 | 0.04 | 0.000 | *0.05* | *0.06* | *0.379* | 0.29 | 0.01 | 0.000 | *0.00* | *0.01* | *0.940* |
| Post-secondary non-tertiary | 0.58 | 0.04 | 0.000 | 0.57 | 0.04 | 0.000 | *0.01* | *0.06* | *0.842* | 0.40 | 0.02 | 0.000 | -0.05 | 0.02 | 0.001 |
| Tertiary first stage | 0.75 | 0.04 | 0.000 | 0.82 | 0.04 | 0.000 | *0.05* | *0.07* | *0.465* | 0.48 | 0.02 | 0.000 | -0.08 | 0.02 | 0.000 |
| Tertiary second state | 0.37 | 0.05 | 0.000 | 0.91 | 0.05 | 0.000 | *-0.08* | *0.06* | *0.169* | 0.54 | 0.02 | 0.000 | -0.13 | 0.02 | 0.000 |
| Not specified | 0.26 | 0.06 | 0.000 | 0.39 | 0.11 | 0.001 | -0.18 | 0.07 | 0.016 | 0.12 | 0.03 | 0.000 | -0.07 | 0.02 | 0.003 |
| Gender (Female) | -0.36 | 0.02 | 0.000 | 0.10 | 0.02 | 0.000 | -0.07 | 0.03 | 0.038 | 0.10 | 0.01 | 0.000 | -0.05 | 0.01 | 0.000 |
| Age: 20-24 (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0-19 | *-0.29* | *0.24* | *0.228* | *-0.06* | *0.36* | *0.873* | -0.97 | 0.39 | 0.012 | 0.44 | 0.09 | 0.000 | *0.04* | *0.09* | *0.607* |
| 25-29 | *0.09* | *0.07* | *0.197* | -0.16 | 0.08 | 0.043 | *-0.20* | *0.11* | *0.070* | -0.09 | 0.03 | 0.003 | *0.02* | *0.03* | *0.612* |
| 30-34 | *0.10* | *0.07* | *0.132* | -0.22 | 0.08 | 0.003 | -0.53 | 0.10 | 0.000 | -0.09 | 0.03 | 0.001 | *0.01* | *0.03* | *0.726* |
| 35-39 | *-0.03* | *0.06* | *0.679* | -0.29 | 0.07 | 0.000 | -0.72 | 0.10 | 0.000 | -0.09 | 0.03 | 0.001 | 0.09 | 0.03 | 0.005 |
| 40-44 | *0.03* | *0.06* | *0.615* | -0.25 | 0.07 | 0.001 | -0.71 | 0.10 | 0.000 | -0.12 | 0.03 | 0.000 | 0.21 | 0.03 | 0.000 |
| 45-49 | *0.04* | *0.06* | *0.480* | -0.23 | 0.07 | 0.002 | -0.60 | 0.10 | 0.000 | -0.17 | 0.03 | 0.000 | 0.31 | 0.03 | 0.000 |
| 50-54 | *0.07* | *0.06* | *0.237* | -0.31 | 0.07 | 0.000 | -0.60 | 0.10 | 0.000 | -0.19 | 0.03 | 0.000 | 0.36 | 0.03 | 0.000 |
| 55-59 | *0.06* | *0.06* | *0.310* | -0.34 | 0.07 | 0.000 | -0.80 | 0.10 | 0.000 | -0.20 | 0.03 | 0.000 | 0.42 | 0.03 | 0.000 |
| 60-64 | *-0.06* | *0.06* | *0.332* | -0.22 | 0.08 | 0.003 | -0.87 | 0.10 | 0.000 | -0.18 | 0.03 | 0.000 | 0.45 | 0.03 | 0.000 |
| 65-69 | *-0.10* | *0.06* | *0.134* | *-0.05* | *0.07* | *0.463* | -0.97 | 0.11 | 0.000 | -0.18 | 0.03 | 0.000 | 0.45 | 0.03 | 0.000 |
| 70-74 | -0.35 | 0.06 | 0.000 | *0.00* | *0.08* | *0.985* | -1.25 | 0.11 | 0.000 | -0.23 | 0.03 | 0.000 | 0.44 | 0.03 | 0.000 |
| >=75 | -0.87 | 0.06 | 0.000 | -0.52 | 0.08 | 0.000 | -1.58 | 0.11 | 0.000 | -0.34 | 0.03 | 0.000 | 0.36 | 0.03 | 0.000 |
| Deg. urb.: Rural areas (ref.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Towns and suburbs | *-0.05* | *0.03* | *0.076* | 0.17 | 0.03 | 0.000 | -0.12 | 0.04 | 0.002 | *-0.01* | *0.01* | *0.244* | -0.05 | 0.01 | 0.000 |
| Cities | -0.64 | 0.02 | 0.000 | 0.32 | 0.02 | 0.000 | -0.33 | 0.03 | 0.000 | *0.01* | *0.01* | *0.311* | -0.09 | 0.01 | 0.000 |
| Country (class variable) | controlled | | | controlled | | | controlled | | | controlled | | | controlled | | |
| R2 | n.a. | | | n.a. | | | n.a. | | | 0.45 | | | 0.26 | | |
| Excluded countries | DK, SI, SE, FI, UK | | | DK, SI, SE, FI, UK | | | DK, SI, SE, FI, UK, BG, LT, SK | | | DK, SI, SE, FI, UK | | | DK, SI, SE, FI, UK, DE | | |

Non-significant results (p>0.05) in cursive

Table A7. The regression coefficient of education and gender indicating their impact on the usage of waste management services

| | 80-100% payed for refuse collection | | | | | | 10%-80% payed for refuse collection | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Countries | CZ, ES, HR, CY, LV | | | CZ, EL, ES, HR, CY, LV, LU | | | BE, BG, EE, IE, LT, HU, PL, PT, SK | | | | | |
| Dependent variable | Waste (d) | | | ln(Waste) | | | Waste (d) | | | ln(Waste) | | |
| | Coef. | Std.Err. | P>\|t\| | Coef. | Std.Err. | P>\|t\| | Coef. | Std.Err. | P>\|t\| | Coef. | Std.Err. | P>\|t\| |
| ln(income per capita) | 0.61 | 0.05 | 0.000 | 0.33 | 0.01 | 0.000 | 0.58 | 0.02 | 0.000 | 0.16 | 0.01 | 0.000 |
| Household size: 1 person (ref.) | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | 0.57 | 0.07 | 0.000 | -0.46 | 0.02 | 0.000 | 0.46 | 0.03 | 0.000 | -0.35 | 0.01 | 0.000 |
| 3 | 1.03 | 0.09 | 0.000 | -0.74 | 0.02 | 0.000 | 0.65 | 0.03 | 0.000 | -0.59 | 0.01 | 0.000 |
| >=4 | 1.14 | 0.09 | 0.000 | -0.97 | 0.03 | 0.000 | 0.74 | 0.04 | 0.000 | -0.83 | 0.01 | 0.000 |
| Education: Primary (ref.) | - | - | - | - | - | - | - | - | - | - | - | - |
| No formal | *-0.16* | *0.16* | *0.320* | -0.10 | 0.04 | 0.005 | *0.03* | *0.06* | *0.656* | *-0.03* | *0.03* | *0.171* |
| Lower secondary | *0.01* | *0.08* | *0.929* | 0.07 | 0.02 | 0.001 | 0.30 | 0.04 | 0.000 | *-0.01* | *0.02* | *0.417* |
| Upper secondary | 0.65 | 0.10 | 0.000 | 0.14 | 0.02 | 0.000 | 0.17 | 0.03 | 0.000 | *0.01* | *0.01* | *0.511* |
| Post-secondary non-tertiary | *-0.12* | *0.09* | *0.214* | 0.08 | 0.03 | 0.006 | 0.28 | 0.05 | 0.000 | *0.00* | *0.02* | *0.959* |
| Tertiary first stage | 1.15 | 0.14 | 0.000 | 0.17 | 0.02 | 0.000 | 0.30 | 0.04 | 0.000 | *-0.01* | *0.01* | *0.563* |
| Tertiary second state | *-0.17* | *0.09* | *0.074* | 0.15 | 0.03 | 0.000 | -0.19 | 0.06 | 0.002 | -0.04 | 0.02 | 0.037 |
| Not specified | n.a. | - | - | 0.45 | 0.10 | 0.000 | *-0.14* | *0.21* | *0.512* | 0.43 | 0.21 | 0.038 |
| Gender (Female) | *0.10* | *0.06* | *0.090* | -0.04 | 0.02 | 0.033 | 0.08 | 0.02 | 0.000 | *-0.01* | *0.01* | *0.136* |
| Age: 20-24 (ref.) | - | - | - | - | - | - | - | - | - | - | - | - |
| 0-19 | *0.90* | *0.73* | *0.218* | *0.15* | *0.12* | *0.225* | *-0.24* | *0.14* | *0.098* | *0.01* | *0.05* | *0.846* |
| 25-29 | *0.37* | *0.22* | *0.089* | *0.07* | *0.13* | *0.564* | *0.06* | *0.06* | *0.339* | 0.06 | 0.02 | 0.006 |
| 30-34 | 0.67 | 0.20 | 0.001 | 0.25 | 0.12 | 0.033 | 0.13 | 0.06 | 0.026 | 0.09 | 0.02 | 0.000 |
| 35-39 | 0.87 | 0.20 | 0.000 | 0.32 | 0.11 | 0.005 | 0.19 | 0.06 | 0.001 | 0.10 | 0.02 | 0.000 |
| 40-44 | 0.97 | 0.20 | 0.000 | 0.33 | 0.12 | 0.004 | 0.23 | 0.06 | 0.000 | 0.14 | 0.02 | 0.000 |
| 45-49 | 1.08 | 0.20 | 0.000 | 0.40 | 0.11 | 0.000 | 0.23 | 0.06 | 0.000 | 0.13 | 0.02 | 0.000 |
| 50-54 | 1.23 | 0.20 | 0.000 | 0.43 | 0.11 | 0.000 | 0.32 | 0.06 | 0.000 | 0.16 | 0.02 | 0.000 |
| 55-59 | 1.34 | 0.20 | 0.000 | 0.42 | 0.11 | 0.000 | 0.42 | 0.06 | 0.000 | 0.17 | 0.02 | 0.000 |
| 60-64 | 1.34 | 0.21 | 0.000 | 0.46 | 0.11 | 0.000 | 0.39 | 0.06 | 0.000 | 0.16 | 0.02 | 0.000 |
| 65-69 | 1.50 | 0.21 | 0.000 | 0.48 | 0.11 | 0.000 | 0.46 | 0.06 | 0.000 | 0.16 | 0.02 | 0.000 |
| 70-74 | 1.88 | 0.21 | 0.000 | 0.45 | 0.11 | 0.000 | 0.48 | 0.06 | 0.000 | 0.14 | 0.02 | 0.000 |
| >=75 | 1.44 | 0.20 | 0.000 | 0.46 | 0.11 | 0.000 | 0.40 | 0.06 | 0.000 | 0.10 | 0.02 | 0.000 |
| Deg. urb.: Rural areas (ref.) | - | - | - | - | - | - | - | - | - | - | - | - |
| Towns and suburbs | -0.32 | 0.07 | 0.000 | 0.16 | 0.02 | 0.000 | -0.06 | 0.03 | 0.030 | 0.13 | 0.01 | 0.000 |
| Cities | -0.86 | 0.06 | 0.000 | 0.04 | 0.01 | 0.015 | 0.38 | 0.02 | 0.000 | 0.08 | 0.01 | 0.000 |
| Country (class variable) | controlled | | | controlled | | | controlled | | | controlled | | |
| R2 | n.a. | | | 0.29 | | | n.a. | | | 0.43 | | |

Non-significant results (p>0.05) in cursive

Table A8. Sample sizes, and income, expenditure and material footprint (including standard error) per capita related to Figure 3

| | | Sample size (households) | Income (2015 €) | Expenditure (2015 €) | Material footprint | Std. error |
|---|---|---|---|---|---|---|
| Northern Europe** | Young (16-24 y.) | 251 | 16 300 | 17 500 | 6.6 | 0.2 |
| | Singles | 902 | 31 000 | 26 000 | 10.4 | 0.2 |
| | Couples | 1531 | 30 800 | 23 000 | 10.0 | 0.1 |
| | Single parents | 156 | 15 900 | 14 300 | 6.1 | 0.2 |
| | Young families (<5 y. child) | 1256 | 18 300 | 14 400 | 6.6 | 0.1 |
| | Families | 570 | 25 100 | 17 100 | 7.4 | 0.1 |
| | Senior singles (>=65 y.) | 574 | 24 200 | 21 300 | 8.6 | 0.2 |
| | Senior couples (>=65 y.) | 771 | 22 800 | 17 900 | 8.1 | 0.1 |
| Western Europe*** | Young (16-24 y.) | 647 | 12 700 | 15 400 | 5.2 | 0.1 |
| | Singles | 6937 | 25 300 | 20 400 | 8.9 | 0.1 |
| | Couples | 7837 | 24 000 | 17 200 | 8.4 | 0.1 |
| | Single parents | 3023 | 10 000 | 10 000 | 4.5 | 0.1 |
| | Young families (<5 y. child) | 5720 | 12 900 | 9 900 | 4.6 | 0.0 |
| | Families | 7708 | 16 100 | 11 800 | 5.7 | 0.0 |
| | Senior singles (>=65 y.) | 3295 | 21 200 | 16 800 | 8.2 | 0.1 |
| | Senior couples (>=65 y.) | 2453 | 18 600 | 14 100 | 7.8 | 0.1 |
| Eastern Europe | Young (16-24 y.) | 922 | 5 600 | 6 000 | 6.6 | 0.1 |
| | Singles | 7721 | 7 000 | 6 800 | 8.5 | 0.1 |
| | Couples | 16473 | 5 500 | 4 700 | 6.6 | 0.0 |
| | Single parents | 3211 | 3 500 | 3 500 | 4.3 | 0.1 |
| | Young families (<5 y. child) | 10987 | 3 400 | 2 900 | 3.4 | 0.0 |
| | Families | 24918 | 3 800 | 3 100 | 4.4 | 0.0 |
| | Senior singles (>=65 y.) | 7404 | 5 300 | 5 100 | 8.2 | 0.1 |
| | Senior couples (>=65 y.) | 5227 | 4 600 | 4 000 | 6.7 | 0.1 |
| Southern Europe | Young (16-24 y.) | 274 | 10400* | 14 600 | 7.2 | 0.2 |
| | Singles | 6325 | 20 000* | 22 700 | 11.0 | 0.1 |
| | Couples | 12855 | 14 900* | 14 900 | 7.6 | 0.0 |
| | Single parents | 1844 | 8 600* | 11 400 | 5.8 | 0.1 |
| | Young families (<5 y. child) | 8402 | 8 400* | 8 900 | 4.6 | 0.0 |
| | Families | 23954 | 10 400* | 10 300 | 5.6 | 0.0 |
| | Senior singles (>=65 y.) | 7254 | 15 700* | 16 500 | 7.9 | 0.1 |
| | Senior couples (>=65 y.) | 6418 | 12 200* | 12 200 | 6.5 | 0.1 |

* Excluding Italy
** Excluding Sweden
*** Excluding Germany

Table A9. Sample sizes, and income, expenditure and material footprint (including standard error) per capita related to Figure 4. Middle-income working-age (25-64 y.) singles.

| Country | Sample size (households) | Income (2015 €) | Expenditure (2015 €) | Material footprint | Std. error | Sample size (households) | Income (2015 €) | Expenditure (2015 €) | Material footprint | Std. error |
|---|---|---|---|---|---|---|---|---|---|---|
| | Repair = 0 | | | | | Repair = 1 | | | | |
| Belgium | 731 | 25 300 | 24 600 | 16.5 | 0.3 | 209 | 26 200 | 26 300 | 18.1 | 0.7 |
| Czech Rep. | 118 | 8 700 | 6 800 | 10.1 | 0.4 | 138 | 9 100 | 7 200 | 10.6 | 0.3 |
| Spain | 732 | 20 500 | 19 700 | 7.3 | 0.2 | 112 | 20 200 | 22 300 | 8.0 | 0.4 |
| Poland | 1 522 | 6 100 | 6 100 | 9.0 | 0.1 | 81 | 6 100 | 6 500 | 8.6 | 0.3 |
| | Public transport = 0 | | | | | Public transport = 1 | | | | |
| Czech Rep. | 60 | 8 900 | 7 100 | 10.4 | 9.2 | 196 | 8 900 | 7 000 | 10.4 | 9.9 |
| Spain | 618 | 20 400 | 19 600 | 7.4 | 7.1 | 226 | 20 700 | 21 000 | 7.1 | 6.6 |
| France | 1 057 | 21 700 | 19 200 | 7.4 | 7.1 | 222 | 22 600 | 22 000 | 7.1 | 6.5 |
| Finland | 137 | 25 200 | 21 500 | 9.8 | 9.0 | 90 | 25 700 | 23 700 | 9.7 | 8.7 |
| | Vegetarian diet = 0 | | | | | Vegetarian diet = 1 | | | | |
| Ireland | 382 | 24 600 | 24 800 | 9.9 | 0.2 | 61 | 23 300 | 21 300 | 7.7 | 0.4 |
| Spain | 735 | 20 600 | 20 300 | 7.6 | 0.2 | 109 | 19 600 | 18 400 | 5.5 | 0.3 |
| Cyprus | 66 | 24 000 | 23 200 | 7.0 | 0.4 | 40 | 25 600 | 24 900 | 6.3 | 0.7 |
| UK | 351 | 17 900 | 15 000 | 7.4 | 0.2 | 49 | 19 500 | 14 400 | 6.1 | 0.5 |