Momentum 2018 - Klasse

Track #10: Ökologie und die soziale Frage;Frage #1: Welche Widersprüche, welche Synergien gibt es beim Adressieren von sozialen und ökologischen Fragen?

Autor: Mag. Andreas Birnstingl
Ökonom und Sozialökologe
Mailto: andreas.birnstingl@gmx.at

Spatial and Socio-Economic Drivers of Direct and Indirect Household Consumption in Austria - An Income Based Approach to Carbon Footprints.

Abstract

Households' carbon footprints are unequally distributed among the rich and poor due to differences in the scale and patterns of consumption. The goal of this study is to provide distributional focused carbon footprints of Austrian households, and to apply carbon footprint Gini and Theil indices to quantify inequalities. The country focus on Austria as a case study of industrialized (welfare) states is a continuation of existing studies on households' carbon footprint in emerging economies like China. Spatial consumption patterns of inequality are analysed and discussed. The drivers of energy consumption for different categories are identified and quantified. Conclusions about the relationship between energy requirements, household characteristics, spatial variables, lifestyle issues - especially concerning vacation destinations - in Austria are drawn. It is expected - analogue to the findings of preceding studies on emerging economies - that its findings will provide categorisation possibilities of classes along income and lifestyle categories, and in a second step implications for policy interventions to encourage stronger sustainable consumption.

Methodology-wise, the study will identify several income groups in Austria based on Konsumerhebung 2009/10 of Statistik Austria and apply statistical techniques focused on clustering instruments along regional, urban-rural, and lifestyle frontlines. The model will be based on an Environmentally Extended Input-Output model and the global Eora Multi-Regional Input-Output (MRIO) Model derived from the GTAP database, using a methodology developed by Lenzen et al. (2012).

In this thesis I would like to test whether influences of socio-economic, geographic and technical effects, that have been previously identified as important for consumption impacts may be apparent also for the Austrian case, comparing the results with previous findings from other studies (e.g. Ivanova et al., 2017) by taking the different data contributions and models into account. Finally, I calculate various inequality indices for the household carbon footprints (HCFs) of households throughout Austria and look for carbon footprint elasticities when giving up cars.

Research questions

- Is there a significant uneven distribution of carbon footprints of households in Austria spatial-wise: regions and/or urban/semi-urban/rural distinction?

- Is there a significant uneven distribution of carbon footprints of households in Austria due to income levels?
- What shows the Gini- and Theil indices by combining spatial and income based analysis?
- Is there a lifestyle pattern when controlling for income by focusing on middle income group only in Vienna/urban/semi-urban/rural areas?
- Same for high income group?
- Are there rebound effects when giving up cars? Where? And in what volume?

Contents

Introduction

In line with the adaption of the 2015 Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC, 2015), the EU and its member states, like most countries in the world, have committed to lower their territorial greenhouse gas (GHG) emissions by 40 % of its 1990 levels in order to limit global temperature rise to 2 °C (Niedertscheider et al., 2018; Rogelj et al., 2016; UNFCCC, 2015) In the EU this is tried to be implemented by the Climate and Energy package (European Commission, 2016) which is part of the Europe growth strategy 2020 (European Commission, 2010). This package consists of two main approaches:

First, the EU Emissions Trading System (EU ETS), which was the first (and still is the biggest) trading system for CO_2-certificates globally (Hartmann, 2014, p. 19). It operates in 31 countries (28 EU countries plus Iceland, Liechtenstein and Norway) and limits emissions from more than 11,000 heavy energy-using installations such as power stations and industrial plants, as well as airlines operating within the 31 countries mentioned above (European Commission, 2018a). The EU ETS covers around 45 % of the EU's greenhouse gas emissions (European Commission, 2018a) and sets its goal to cut emissions by 21 % by 2020 and by 43 % by 2030 (European Commission, 2018b).

Second, the Effort Sharing legislation establishes binding annual greenhouse gas emission targets for Member States for the periods 2013–2020 and 2021–2030. Until October 2018, the national targets together indented to deliver a reduction of 10 % in total EU emissions by 2020 and of 30% by 2030, compared with 2005 levels (European Commission, 2018b). In an agreed European Council position these targets were strengthened to 15 % and 35 % respectively (European Council, 2018). These targets concern emissions from most sectors not included in the EU ETS, such as transport, buildings, agriculture and waste. Binding targets are set for each EU Member State, which are based on the Member State's relative wealth, measured in GDP per capita of its inhabitants. As for Austria, a reduction of CO_2 emissions of 16 % by 2020 was agreed as target, and of 36 % by 2030 (European Commission, 2018b).

End of June 2018, the government of Austria presented its national strategy how to achieve these targets. Focus is put on better thermal isolation of buildings and settlements and the increase of household-based energy production like e.g. with the intended installment of additional 100,000 photo-voltaic micro-plants on rooftops. From 2020 onward, there shall be a ban of installing new heating oil based heating systems in households, and Austria's total demand for electricity should be fed 100% from renewable sources by 2030.

Whereas 14 billion Euro are bookmarked to be invested in the transport sector - the biggest cause of CO_2 emissions (mainly in railway services, extension of e-mobility and biking) - other major emitting sectors not included in the EU ETS will not be targeted. Especially industry and agriculture are exempt from the 2030 mission of the Austrian government (Bundesministerium für Nachhaltigkeit und Tourismus and Bundesministerium für Verkehr, Innovation und Technologie, 2018). Critics also argue that the tax system is still not tackled and shifted from income based towards a wealth and environmental based tax system (e.g. IMF, 2018; Kettner-Marx et al., 2018; OECD, 2017, 2015, 2013) and that indented reforms of laws and procedures testing environmental sustainability of infrastructure projects, will contravene attempts to achieve the 2030 climate targets.

Production-Based and Consumption-Based Accounting

All these strategies and targets are referring to a production based (PB) approach, meaning that only emissions occurring within the territory of a given entity are counted. PB-based means that while enterprises, households and governments within this entity consume *direct requirements* - like e.g. energy carriers such as heating and cooking fuels, electricity or petrol for driving a car - they produce emissions. As PB accounting looks only at these direct emissions, it is conceptually and methodologically more straightforward, but it suffers from the fact that it cannot take upstream, indirect or embodied requirements and emissions of activities happening outside a certain entity into account (Lenzen et al., 2008; Liu et al., 2010; Hertwich and Peters, 2008; Afionis et al., 2017; Wiedenhofer, 2011).

In order to include emissions in the process of production and delivery, several studies suggest that the focus should shift to a consumption-based approach (CB). CB accounting regards emissions at the point of consumption, which means that it is the final consumer whom the embodied emissions are attributed to, instead of the producer of goods and services. "The main difference, therefore, between the PB and CB accounting approaches is that application of the latter would entail a state with an abatement policy to cede responsibility for emissions associated with its export production and accept responsibility for the 'embodied' or 'virtual' emissions of its imported goods and services." (Afionis et al., 2017, p. 3; Steininger et al., 2014)

This means, to address these attributed emissions, net importing countries could strengthen emissions reductions within their territories, reduce the consumption levels of their residents, or contribute to mitigation efforts in foreign countries. Switching from a PB to a CB accounting system would have important implications for global mitigation policies and consumption patterns, given that 20–25% of overall carbon dioxide emissions are from international trade (Barrett et al., 2013; Davis and Caldeira, 2010; Hertwich and Peters, 2008; Muñoz and Steininger, 2010; Peters et al., 2011; Wiedmann et al., 2013). As a general picture, due to growing international trade, these global CO_2 and other GHG emissions are bound to continue rising.

Policy relevance

While PB accounting is currently the UNFCCC's adopted accounting principle, emissions embodied in trade are rapidly increasing and there is thus a growing gap between production emissions and the emissions associated with consumption. This is of concern due to the absence of a global cap and significant variation in country-level mitigation ambitions. In identifying the main drivers for CB emissions, new policy mechanisms could potentially be utilized and could unlock new opportunities for climate policy innovation and for climate mitigation. (Afionis et al., 2017)

This includes trade-related policy like border carbon adjustments (Hertwich and Peters, 2008; Steininger et al., 2014), domestic policies like resource and energy efficiency, as well as consumption targeted mitigation strategies (Barrett et al., 2013; Lorek and Spangenberg, 2014). As climate policy targets deepen, there is a need for a broad range of policy options in addition to production and technological solutions (Afionis et al., 2017; Barrett et al., 2013).

This development has led to increased calls for a switch to, or an amalgamation with, other accounting approaches (Afionis et al., 2017; Barrett et al., 2013; Steininger et al., 2014). Steininger et al. (2014) emphasise the latter option also from a perspective of justice and economic efficiency. According to them, CB emissions could be handled complementary to PB emissions inventories. in that sense that emissions should be understood as, "being contributed by both, consumers and producers, but that this fact does not by itself settle the question whether consumption or production ought to serve as the climate policy base." (ibid.)

Apart from the discussion of a complete switch (Afionis et al., 2017), Steininger et al. (2014) find that, under the conditions of clean technology transfers, border carbon adjustments, and distribution of these import tax revenues to developing countries, the "global cost-effectiveness and justice can be improved if the unilateral climate policies of industrialized countries are based on emissions from consumption." (Steininger et al., 2014) These conditions are essential, as also shown by (Jakob et al., 2013, p. 19; Jakob and Marschinski, 2013), because only, "if consumption-based emission pricing were not based on actual net imports of embodied emissions but on those calculated under a best-available technology approach, it would result in less leakage than production-based emission pricing." The argument goes that due to the fact that usually export-oriented sectors are less carbon intensive (Davis and Caldeira, 2010), only the distribution of best-clean-technology could, after any introduction of border tariffs, prevent the shift of production to more carbon intensive, inward-oriented sectors (due to old technology). This gives again rise to the discussion of implementing an international technology fund (UNEP, 2011).

Equity and justice concerns have been of paramount significance in international negotiations on climate change ever since the adoption of the UNFCCC in 1992. As for a fair allocation of responsibility for GHG emissions, neither a pure CB nor only PB approach seems to satisfy (Afionis et al., 2017), hence, the concept of shared responsibility has recently been advanced. To overcome this issue a consistent approach covering the complete life-cycle of all products and services, while avoiding problems of double-counting, has been formulated (Gallego and Lenzen, 2005; Lenzen and Murray, 2010). In this approach, "responsibilities for indirect requirements are shared between consumer and producer, either half / half or in relation to the value added, thereby explicitly linking responsibility with economic influence." (Wiedenhofer, 2011, p. 9) A detailed discussion on accounting responsibility and various stakeholder views is provided in (Afionis et al., 2017; Jakob et al., 2013; Jakob and Marschinski, 2013; Lenzen et al., 2007; Muñoz and Steininger, 2010; Steininger et al., 2014). For this study, a consistent, consumption-based perspective on the drivers of carbon footprint of Austrian households was applied.

Subnational level

Differences between PB and CB approaches also refer to spatial heterogeneity within countries. Barrett et al. (2013) and others point out (e.g. Afionis et al., 2017; Chancel and Piketty, 2015; Steininger et al., 2014; Wiedmann et al., 2013) that: "without consumption-based approaches, territorial emissions alone will not provide a complete picture of progress in regional and national emissions reduction." From a CB perspective it can be argued that in the case of Austria - being rather a relatively small, open and trade-linked economy - differences between the CB carbon footprint of its regions (e.g. Ivanova et al., 2017) and/or of rural-urban settlements (e.g. Czepkiewicz et al., 2018; Heinonen et al., 2013a, 2013b; Ottelin et al., 2017) could be rather big. As previous CB studies concluded that around half of the total carbon footprint of Austria originates outside of its borders (Ivanova et al., 2017; Kanemoto et al., 2014; Muñoz and Steininger, 2010) - caused mainly due to consumption of embodied CO_2 and other GHGs in commodities and services - differing demand patterns in regions and income classes could be investigated and more accurately tackled policy wise.

Since the turn of the millennium, ever more scientific studies capturing the CB approach show that PB cross-country analyses conceal that the carbon footprint of regions, areas or income groups within countries differ rather widely, which may potentially obstruct the effect of (PB based) impact mitigation policies (e.g. Chancel and Piketty, 2015; Czepkiewicz et al., 2018; Godar et al., 2015; Heinonen et al., 2013a, 2013b; Ivanova et al., 2017; Ottelin et al., 2017; Wiedenhofer, 2011; Wiedenhofer et al., 2016). "Today, within-country inequality makes up 50 % of the global dispersion of CO_2 emissions. It is then crucial to focus on high individual emitters rather than high emitting countries." (Chancel and Piketty, 2015, p. 9) For example, Wiedenhofer et al. (2016) found that the top 5 % richest households (income wise) in urban China emitted 19 % of all of China's CO_2 emissions in 2012.

In the EU Commission's "Flagship Initiative for a Resource Efficient Europe" (European Commission, 2011a) - a so called Communication to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions - as well as in its staff working document "Regional Policy contributing to sustainable growth in Europe 2020"(European Commission, 2011b), the EU Commission also recommended that environmental affairs should be dealt with on a sub-national level too. As Afionis et al. (2017) point out, a CB approach could be quite helpful in order to identify the main concerns in regards to sustainability on a sub-national level. By identifying feedback loops and rebound effects to emission reduction policy implementations, the CB accounting approach could help regional governments to tackle the most urgent shortfalls and provide precise and target-oriented mitigation strategies.

As for the whole European Union, the study of Ivanova et al. (2017) was just recently funded by the European Commission's GLAMURS Programme and states in its description: "This is the first study to quantify the GHG emissions associated with household consumption at a regional scale across the EU, providing unique insights into carbon footprints across Member States. The data from the survey could be used to drive local decision-making processes, including designing and monitoring more intelligent regional climate mitigation policies."

There already exist several studies on the sub-national level of countries worldwide and its respective consumption sectors, both in regards to carbon footprints as well as energy requirements. They look usually either on differences between regions or focus on the spatial dichotomy of rural-urban characteristics.

- Australia (Lenzen et al., 2006, 2004; Wiedenhofer, 2011; Wiedenhofer et al., 2013),
- Baltics, namely Estonia, Latvia and Lithuania (Brizga et al., 2017)
- Brazil (Cohen et al., 2005; Lenzen et al., 2006),
- China and Hongkong (Clarke-Sather et al., 2011; Deng et al., 2016; Fan et al., 2012; Harris et al., 2012; Wiedenhofer et al., 2016; Zhang and Anadon, 2014; Zhou and Imura, 2011),
- Denmark (Lenzen et al., 2006),
- European Union (Ivanova et al., 2017)
- Finland (Ala-Mantila et al., 2014; Heinonen et al., 2013b, 2013a, 2011; Ottelin et al., 2015)
- Germany (Miehe et al., 2016),
- India (Ahmad et al., 2015; Lenzen et al., 2006),
- Japan (Hasegawa et al., 2015; Lenzen et al., 2006),
- Norway (Larsen and Hertwich, 2011; Steen-Olsen et al., 2016),
- Pakistan (Adnan et al., 2018)
- Spain (Arce et al., 2017),
- UK, in general as well as for its sub-regions (Baiocchi et al., 2015, 2010a; Brand, 2009; Brand and Boardman, 2008; Brand and Preston, 2010; Chitnis et al., 2014, 2013; Curry and Maguire, 2011; Druckman et al., 2011; Jackson and Papathanasopoulou, 2008; Minx et al., 2013),
- United States (Adom et al., 2013; Jones and Kammen, 2014, 2011) with Adom et al (2013) using a LCA approach,

Everyday Life

Aspects of "everyday life" (which includes issues of lifestyles) is another important approach which CB accounting can help to shed light onto. Especially, studies based on a segregation between low- and high density settlements, provided new insights by adopting this methodology, which would have been hard to find when only relying on the PB perspective.

Emission intensity is the emission rate of a given pollutant, like e.g. CO_2, relative to the intensity of a specific activity, or an industrial production process; for example the ratio of CO_2 produced per unit of GDP (e.g. per Euro). Carbon intensity can thus be defined as the amount of CO_2 emission per currency unit spent. This provides an interesting approach as Wiedenhofer (2011, p. 6) in reference to Herendeen (1978) points out: “a consumer's dollar [or Euro] can be spent with significantly different energy [or carbon] impact.” This approach allows the investigation of the consequences of different consumption patterns based on contributing variables like income or the size of households, as well as possibilities for reductions in the carbon footprint through shifts in these patterns (Fischer-Kowalski et al., 2013; Fischer-Kowalski and Haberl, 2007; Lorek and Spangenberg, 2014; Max-Neef, 1989; Wiedenhofer, 2011, p. 6; Wilson et al., 2013)

As the latter relies basically on the direct measurement of emissions, the identified main contributors are housing and transport. Hence, the argument goes that the denser human settlements are, the more energy-efficient (and thus more CO_2-efficient) housing and transportation gets due to the advantages of a compact network of e.g. public transport (no need for cars) and district heating (no need for e.g. heating oil or coal).

On the other hand, however, some CB carbon footprint studies also show that when all the GHG emissions related to the consumption of services, goods and energy are taken into account, the question of sustainable urban structure is getting more complicated - to that point that no clear evidence on the superiority of dense urban structures can be claimed (Ala-Mantila et al., 2014; Baiocchi et al., 2010b; Czepkiewicz et al., 2018; Heinonen et al., 2013a, 2013b, 2011; Lenzen et al., 2004; Minx et al., 2013; Ottelin et al., 2017, 2015; Wiedenhofer et al., 2013). Also the 5th Assessment Report of the (Intergovernmental Panel on Climate Change et al., 2014) addresses the differences due to chosen boundaries of reported emissions. In this sense, as (Ottelin et al., 2017) point out, traditional research on transport and travel behavior could use the CB approach to measure the rebound effect of consumption when e.g. cars are abandoned.

In this sense, the research community is arguing, that it is not only increasingly important to focus on regional and local policy for environmental impact mitigation (e.g. Meng et al., 2013 and Harris et al., 2012), but also, in order to gain insights for efficient and streamlined policy measures when necessary, to take homogeneous lifestyles and similar patterns and levels of carbon footprint of different clusters of consumers into account (Abrahamse and Steg, 2009; Baiocchi et al., 2010b; Chancel and Piketty, 2015; Curry and Maguire, 2011; Czepkiewicz et al., 2018; Jackson and Papathanasopoulou, 2008; Lenzen et al., 2004; Miehe et al., 2016; Minx et al., 2013; Newton and Meyer, 2012; Reinders et al., 2003; Wiedenhofer et al., 2016, 2016; Wilson et al., 2013; Zhou and Imura, 2011) and also referring to the significant impact of public services and public procurement decisions (Larsen and Hertwich, 2011).

Independent variables

In this study, a multivariable regression model to explore the relationships between household carbon footprints as the dependent variable and several predicting independent factors was applied. Prior studies provide a lot of information about the relevant drivers of variation in carbon footprints. Following the categorization of (Ivanova et al., 2017) these drivers can be roughly grouped into three effects, namely:

a) ***socio-economic*** such as income, household size, education, social status and degree of urbanization (Jones and Kammen, 2011, 2014; Baiocchi et al., 2010b; Minx et al., 2013; Wilson et al., 2013),

b) ***geographic*** such as temperature and geographic location (Newton and Meyer, 2012; Tukker et al., 2010) and

c) ***technical*** such as the infrastructural context (Sanne, 2002; Tukker et al., 2010).

Multivariate analysis has been widely applied to study carbon footprints for households in terms of different characteristics. The following paragraph provides an extensive literature review on these variables. A short summary of promising predicting variables, descriptions and sources of multiple empirical studies and theoretical considerations which led the decision making process of which variables to include can also be found in **Error! Reference source not found.**.

Socio-economic drivers

Income

Across all studies, income / expenditure has been identified as the main independent driver of carbon footprints or total energy consumption of households (e.g. Duarte et al., 2012; Hertwich and Peters, 2008; Jackson and Papathanasopoulou, 2008; Lenzen et al., 2006, 2004; Marcotullio et al., 2014; Reinders et al., 2003; Tukker et al., 2010; Wier et al., 2001; Wilson et al., 2013). Expenditure is usually preferred to income as a predictor, because it corresponds more closely to what households actually consume. Expenditure includes: "social benefit transfers and various non-consumption expenses are already deducted, for example savings, taxes, donations and fines" (Wiedenhofer, 2011, p. 16).

Existing literature already recognized strong correlations between income/expenditure and several other variables usually available from CES. Energy-wise, Lenzen et al. (2004) and Reinders et al. (2003) find that indirect/embedded energy consumption is closer correlated to income than direct demand.

Education

As for education, findings in previous studies appear to contradict each other. Applying a multivariate framework and controlling for expenditures, e.g. no significant impact of higher education on energy demand has been found for Japan and Denmark. (Baiocchi et al., 2010a; Lenzen et al., 2006), whereas Lenzen et al. (2004) identified a weak negative influence of education on energy demand in Australia and the United Kingdom. This might indicate possibilities for educated ‘green consumerism’ (Baiocchi et al., 2010a), while Abrahamse and Steg (2009) point out, that while existing requirement patterns are explained quite well by socio-economic variables, energy savings and changes in consumption are much more associated with psychological factors. (education not included in their model though) or by common social values shared within the neighbourhood (Heinonen et al., 2013a, 2013b). Chancel and Piketty (2015) also find that education and social status have an impact on emission-intensive lifestyles - with higher income the carbon footprint increases and vice versa.

Interestingly for developing countries like India and Brazil, a positive link between education and total requirements has been reported (Cohen et al., 2005; Lenzen et al., 2006), where it has been hypothesized that especially urban educated individuals emulate a western consumerist lifestyle, which includes an ongoing accumulation of household stocks and consumer goods.

In order to prevent straight colinearity between income, age and education level, Ivanova et al. (2017) use the percentage of the population aged 30-34 with tertiary education as a proxy in their modeling.

Age

Although age is highly correlated with the education and income level of households (or the heads thereof), controlling for these factors provide a small remaining effect. Whereas in the case of Australia this effect was found to be positive (Wiedenhofer, 2011; Lenzen et al., 2006) with explanations including higher automobile mobility of independent retirees, larger residential energy requirements because of higher home stay rates compared to working population, or aged peoples' need for higher indoor temperatures; a study on ageing society in Japan found a negative impact of age, mainly due to lower consumption demand (Shigetomi et al., 2014).

Gender

Another rather problematic variable in terms of significant aspects on household carbon footprints is gender. In Wiedenhofer (2011) one study on this issue was cited (Räty and Carlsson-Kanyama, 2010), extracting a quote thereof: "[Single] women consistently used more energy than men […] [for] food, hygiene, household effects and health although differences are rather small." (Räty and Carlsson-Kanyama, 2010, p. 648). In the same study it was also concluded that single men households in total have a larger carbon footprint mainly due to transportation and the 'restaurants, alcohol and tobacco' category. However, as also pointed out by Wiedenhofer (2011), the authors did not control for income, which might outdo any of these findings. Consequently, Wiedenhofer (2011) could not attribute any gender specific patterns in his study on energy requirements of Australian households when controlling for income.

Type of settlement

This variable comprises several categories identified in literature. One is household composition and its size, meaning how many people live in a household. As this will influence the outcome and comparability, it must be controlled for. Household members share electrical appliances and require less individual living space. Also, there exist economies of scale in different consumption domains (Lenzen et al., 2006; Minx et al., 2013; Tukker et al., 2010; Wilson et al., 2013).

Housing type and size also matters as housing size determines directly the requirements of space heating and/or cooling, and indirectly through construction needs and building material use (Lenzen et al. 2004; Lenzen et al., 2006; Newton and Meyer, 2012).

Population density is another important predicting variable. For several countries, a correlation with energy demand and carbon footprints has been found for the density of people living in a settlement (especially urban) even when expenditure is being controlled for (Ala-Mantila et al., 2014; Czepkiewicz et al., 2018; Heinonen et al., 2013a, 2013b, 2011; Lenzen et al., 2006; Ottelin et al., 2017; Wiedenhofer, 2011). In line with Munksgaard et al. (2008, p. 180) who concluded that, "[…] families living in rural houses perform the worst in terms of environmental friendliness, based on their relatively high consumption of energy and transportation", urban typology is in many studies associated with more compact development and larger availability of public transport. However, other studies have also found urban inhabitants to have higher impacts associated with food, leisure travel and manufactured products (Fremstad et al., 2018; Jones and Kammen, 2014; Marcotullio et al., 2014; Minx et al., 2013; Tukker et al., 2010; Wiedenhofer et al., 2013). Urban households show consistently higher levels of total energy and CO_2 requirements than suburban or rural households, largely because of their higher incomes (Lenzen, 1998a; Wier et al., 2001; Lenzen et al., 2004) causing rebound effects in terms of higher consumption (Ala-Mantila et al., 2014; Czepkiewicz et al., 2018; Heinonen et al., 2013a, 2013b, 2011; Ottelin et al., 2015; Wiedenhofer et al., 2013). The conclusion of this contradiction could be that, "when differences in income are being controlled for, rural and sprawl living is comparatively more resource and energy intensive than urban lifestyles, mostly because of the larger share of transportation and residential energy requirements. Inherently positive aspects of urban lifestyle are negated by significantly higher incomes and a generally more affluent lifestyle." (Wiedenhofer, 2011, p. 15, in reference to; Lenzen et al., 2008)

Transportation
Closely related to the type of settlement are factors of transportation. These factors are mostly addressed in urban development planning studies.

Others
The demand for and consumption of agriculture products (Jones et al., 2002; Kissinger, 2012; López et al., 2015; Pirog et al., 2001; Pirog and Benjamin, 2005, 2003; Waye, 2008; Weber and Matthews, 2008) and tourism consumption (mostly in Spain) and its seasonal variability (Cadarso et al., 2016; Duro and Farré, 2015; Turrión-Prats and Duro, 2017) are another two independent variables used to explain variations in carbon footprints in the socio-economic category. Noteworthy is that tourism and transport sectors are potentially more affected by residents' spending abroad, which may bring about higher uncertainty of results in those sectors (Ivanova et al., 2017; Usubiaga and Acosta-Fernández, 2015) - an issue which might be circumvented by applying Multi-Regional Input-Output tables.

Geographical drivers

Climate
Lower average temperatures (mountains) and rather dispersed habitat are associated with higher emissions (HDD). Rising temperatures may also drive energy use for cooling (CDD).(Chancel and Piketty, 2015; Minx et al., 2013; Wiedenhofer et al., 2013) As heating is one of the main direct energy requirements and thus intensive in carbon emissions, different climate conditions in Austria have to be taken into account.

Forests
Another variable in terms of geographical categories is access to forests and semi-natural areas as an incentive for low carbon intensive recreational activities and consumption of local products (Ivanova et al., 2017, 2015).

Technical drivers

Energy mix
The energy mix of households (Ivanova et al., 2017; Tukker et al., 2010). The local electricity mix directly determines the carbon intensity of products produced and consumed locally (e.g. housing emissions).

Infrastructure

Infrastructure and access to it is closely related to transport as it includes e.g. access to public transport. As this is somewhat better covered and more correlated to socio-economic drivers like income (esp. when it comes to flights) and population density, this study does not include this aspect on this level. Access to airports, on the other hand, seems to be a driving factor in this category and might be relevant to shed more light on it in the case of Vienna and its intended increase of capacity of its airport in Vienna-Schwechat. However, as this is yet to come, this variable was not modelled in this study.

The same argument holds for the intended closure of a motorway-ring around the capital Vienna via the construction of a tunnel beneath the National Park Donau-Auen (Vienna, together with Nairobi, Kenya, being one of the two capitals worldwide only with a National Park within its borders). Although it might be interesting to test if this attempt would counteract the geographical driver identified by Ivanova et al. (2017, 2015), that access to forests drives down the carbon footprint of households due to incentives of low carbon intensive leisure time activities like walking, swimming or cycling.

Bibliography

Abrahamse, W., Steg, L., 2009. How do Socio-Demographic and Psychological Factors relate to Households' direct and indirect Energy Use and Savings? Journal of Economic Psychology 30, 711–720. https://doi.org/10.1016/j.joep.2009.05.006

Adnan, M.N., Safeer, R., Rashid, A., 2018. Consumption Based Approach of Carbon Footprint Analysis in Urban Slum and Non-Slum Areas of Rawalpindi. Habitat International 73, 16–24. https://doi.org/10.1016/j.habitatint.2017.12.012

Adom, F., Workman, C., Thoma, G., Shonnard, D., 2013. Carbon footprint analysis of dairy feed from a mill in Michigan, USA. International Dairy Journal 31, S21–S28. https://doi.org/10.1016/j.idairyj.2012.09.008

Afionis, S., Sakai, M., Scott, K., Barrett, J., Gouldson, A., 2017. Consumption-based Carbon Accounting: Does it have a Future? Wiley Interdisciplinary Reviews: Climate Change 8, e438. https://doi.org/10.1002/wcc.438

Ahmad, S., Baiocchi, G., Creutzig, F., 2015. Emissions from Direct Energy Use of Urban Households in India. Environmental Science & Technology 49, 11312–11320. https://doi.org/10.1021/es505814g

Ala-Mantila, S., Heinonen, J., Junnila, S., 2014. Relationship between Urbanization, direct and indirect Greenhouse Gas Emissions, and Expenditures: A multivariate Analysis. Ecological Economics 104, 129–139. https://doi.org/10.1016/j.ecolecon.2014.04.019

Arce, G., Zafrilla, J.E., López, L.-A., Tobarra, M.Á., 2017. Carbon Footprint of Human Settlements in Spain, in: Álvarez Fernández, R., Zubelzu, S., Martínez, R. (Eds.), Carbon Footprint and the Industrial Life Cycle. Springer International Publishing, Cham, pp. 307–324. https://doi.org/10.1007/978-3-319-54984-2_14

Baiocchi, G., Creutzig, F., Minx, J., Pichler, P.-P., 2015. A Spatial Typology of Human Settlements and their CO2 Emissions in England. Global Environmental Change 34, 13–21. https://doi.org/10.1016/j.gloenvcha.2015.06.001

Baiocchi, G., Minx, J., Hubacek, K., 2010a. The Impact of Social Factors and Consumer Behavior on Carbon Dioxide Emissions in the United Kingdom: A Regression Based on Input−Output and Geodemographic Consumer Segmentation Data. Journal of Industrial Ecology 14, 50–72. https://doi.org/10.1111/j.1530-9290.2009.00216.x

Baiocchi, G., Minx, J., Hubacek, K., 2010b. The Impact of Social Factors and Consumer Behavior on Carbon Dioxide Emissions in the United Kingdom. Journal of Industrial Ecology 14, 50–72. https://doi.org/10.1111/j.1530- 9290.2009.00216.x.

Barrett, J., Peters, G., Wiedmann, T., Scott, K., Lenzen, M., Roelich, K., Le Quéré, C., 2013. Consumption-Based GHG Emission Accounting: A UK Case Study. Climate Policy 13, 451–470. https://doi.org/10.1080/14693062.2013.788858

Brand, C., 2009. "Hockey Sticks" Made of Carbon: Unequal Distribution of Greenhouse Gas Emissions from Personal Travel in the United Kingdom. Transportation Research Record: Journal of the Transportation Research Board 2139, 88–96. https://doi.org/10.3141/2139-11

Brand, C., Boardman, B., 2008. Taming of the Few -The unequal Distribution of Greenhouse Gas Emissions from personal Travel in the UK. Energy Policy 36, 224–238. https://doi.org/10.1016/j.enpol.2007.08.016

Brand, C., Preston, J.M., 2010. ‘60-20 Emission’ -The unequal Distribution of Greenhouse Gas Emissions from personal, non-business Travel in the UK. Transport Policy 17, 9–19. https://doi.org/10.1016/j.tranpol.2009.09.001

Brizga, J., Feng, K., Hubacek, K., 2017. Household Carbon Footprints in the Baltic States: A Global Multi-Regional Input–Output Analysis from 1995 to 2011. Applied Energy 189, 780–788. https://doi.org/10.1016/j.apenergy.2016.01.102

Bundesministerium für Nachhaltigkeit und Tourismus, Bundesministerium für Verkehr, Innovation und Technologie, 2018. #mission 2030 - Die österreichische Klima- und Energiestrategie. Wien, Österreich.

Cadarso, M.Á., Gómez, N., López, L.A., Tobarra, M.Á., 2016. Calculating Tourism’s Carbon Footprint: Measuring the Impact of Investments. Journal of Cleaner Production 111, 529–537. https://doi.org/10.1016/j.jclepro.2014.09.019

Chancel, L., Piketty, T., 2015. Carbon and Inequality: From Kyoto to Paris.

Chitnis, M., Sorrell, S., Druckman, A., Firth, S.K., Jackson, T., 2014. Who rebounds most? Estimating direct and indirect Rebound Effects for different UK socioeconomic Groups. Ecological Economics 106, 12–32. https://doi.org/10.1016/j.ecolecon.2014.07.003

Chitnis, M., Sorrell, S., Druckman, A., Firth, S.K., Jackson, T., 2013. Turning Lights into Flights: Estimating direct and indirect Rebound Effects for UK Households. Energy Policy 55, 234–250. https://doi.org/10.1016/j.enpol.2012.12.008

Clarke-Sather, A., Qu, J., Wang, Q., Zeng, J., Li, Y., 2011. Carbon Inequality at the Sub-National Scale: A Case Study of Provincial-Level Inequality in CO2 Emissions in China 1997–2007. Energy Policy 39, 5420–5428. https://doi.org/10.1016/j.enpol.2011.05.021

Cohen, C., Lenzen, M., Schaeffer, R., 2005. Energy Requirements of Households in Brazil. Energy Policy 33, 555–562. https://doi.org/10.1016/j.enpol.2003.08.021

Curry, R., Maguire, C., 2011. The Use of Ecological and Carbon Footprint Analysis in Regional Policy Making: Application and Insights Using the REAP Model. Local Environment 16, 917–936. https://doi.org/10.1080/13549839.2011.615306

Czepkiewicz, M., Heinonen, J., Ottelin, J., 2018. Why do Urbanites travel more than do Others? A Review of Associations between Urban Form and Long-Distance Leisure Travel. Environmentatl Research Letters 13, 1–29. https://doi.org/10.1088/1748-9326/aac9d2

Davis, S.J., Caldeira, K., 2010. Consumption-Based Accounting of CO2 Emissions. Proceedings of the National Academy of Sciences 107, 5687–5692. https://doi.org/10.1073/pnas.0906974107

Deng, G., Ma, Y., Li, X., 2016. Regional Water Footprint Evaluation and Trend Analysis of China - Based on Interregional Input–Output Model. Journal of Cleaner Production 112, 4674–4682. https://doi.org/10.1016/j.jclepro.2015.07.129

Druckman, A., Chitnis, M., Sorrell, S., Jackson, T., 2011. Missing Carbon Reductions? Exploring Rebound and Backfire Effects in UK Households. Energy Policy 49, 778. https://doi.org/10.1016/j.enpol.2012.06.045

Duarte, R., Mainar, A., Sánchez-Chóliz, J., 2012. Social Groups and CO2 Emissions in Spanish Households. Energy Policy 44, 441–450. https://doi.org/10.1016/j.enpol.2012.02.020

Duro, J.A., Farré, F.X., 2015. Tourist Season in the Spanish Provinces: Measurement and Analysis. Cuadernos de Turismo 457–459.

European Commission, 2016. Climate Strategies and Targets: 2020 Climate and Energy Package.

European Commission, 2010. Europe 2020. A Strategy for Smart, Sustainable and Inclusive Growth.

European Commission, 2018a. The EU Emissions Trading System (EU ETS).

European Commission, 2018b. Effort Sharing: Member States’ Emission Targets.

European Commission, 2011a. A Resource-Efficient Europe – Flagship Initiative under the Europe 2020 Strategy.

European Commission, 2011b. Regional Policy contributing to Sustainable Growth in Europe 2020.

European Council, 2018. CO2 Emission Standards for Cars and Vans: Council Agrees its Position.

Fan, J., Guo, X., Marinova, D., Wu, Y., Zhao, D., 2012. Embedded Carbon Footprint of Chinese Urban Households: Structure and Changes. Journal of Cleaner Production 33, 50–59. https://doi.org/10.1016/j.jclepro.2012.05.018

Fischer-Kowalski, M., Haberl, H., 2007. Conceptualizing, Observing and Comparing Social Transitions.

Fischer-Kowalski, M., Mayer, A., Hausknost, D., 2013. Umwelt und Soziale Ökologie, in: Flicker, E., Forster, R. (Eds.), Forschungs- Und Anwendungsfelder Der Soziologie. facultas.wuv, pp. 251–267.

Fremstad, A., Underwood, A., Zahran, S., 2018. The Environmental Impact of Sharing: Household and Urban Economies in CO 2 Emissions. Ecological Economics 145, 137–147. https://doi.org/10.1016/j.ecolecon.2017.08.024

Gallego, B., Lenzen, M., 2005. A consistent Input–Output Formulation of shared Producer and Consumer Responsibility. Economic Systems Research 17, 365–391. https://doi.org/10.1080/09535310500283492

Godar, J., Persson, U.M., Tizado, E.J., Meyfroidt, P., 2015. Towards more Accurate and Policy Relevant Footprint Analyses: Tracing Fine-Scale Socio-Environmental Impacts of Production to Consumption. Ecological Economics 112, 25–35.

Harris, P.G., Chow, A.S.Y., Symons, J., 2012. Greenhouse Gas Emissions from Cities and Regions: International Implications revealed by Hong Kong. Energy Policy 44, 416–24. https://doi.org/10.1016/j.enpol.2012.02.012
Hartmann, N., 2014. Der Europäische Emissionszertifikathandel - Ein wirksames Klimaschutzinstrument?, Wirtschaftspolitische Forschungsarbeiten der Universität zu Köln. Tectum, Marburg.
Hasegawa, R., Kagawa, S., Tsukui, M., 2015. Carbon Footprint Analysis Through Constructing a Multi-Region Input–Output Table: A Case Study of Japan. Journal of Economic Structures 4. https://doi.org/10.1186/s40008-015-0015-6
Heinonen, J., Jalas, M., Juntunen, J.K., Ala-Mantila, S., Junnila, S., 2013a. Situated Lifestyles: I. How Lifestyles change along with the Level of Urbanization and what the Greenhouse Gas Implications are - A Study of Finland. Environmental Research Letters 8, 025003. https://doi.org/10.1088/1748-9326/8/2/025003
Heinonen, J., Jalas, M., Juntunen, J.K., Ala-Mantila, S., Junnila, S., 2013b. Situated Lifestyles: II. The Impacts of Urban Density, Housing Type and Motorization on the Greenhouse Gas Emissions of the Middle-Income Consumers in Finland. Environmental Research Letters 8, 035050. https://doi.org/10.1088/1748-9326/8/3/035050
Heinonen, J., Kyrö, R., Junnila, S., 2011. Dense Downtown Living more Carbon intense due to higher Consumption: A Case Study of Helsinki. Environmental Research Letters 6, 034034. https://doi.org/10.1088/1748-9326/6/3/034034
Herendeen, R., 1978. Total Energy Cost of Household Consumption in Norway, 1973. Energy 3, 615–630. https://doi.org/10.1016/0360-5442(78)90077-4
Hertwich, E.G., Peters, G.P., 2008. CO2 Embodied in International Trade with Implications for Global Climate Policy. Environmental Science & Technology 42, 1401–1407. https://doi.org/10.1021/es072023k
IMF, 2018. Austria: Staff Concluding Statement of the 2018 Article IV Mission.
Intergovernmental Panel on Climate Change, Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Minx, J.C., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S. (Eds.), 2014. Climate Change 2014: Mitigation of Climate Change: Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York, NY.
Ivanova, D., Stadler, K., Steen-Olsen, K., Hertwich, E.G., 2015. Environmental Impact Assessment of Household Consumption. Journal of Industrial Ecology 20, 526–536. https://doi.org/10.1111/jiec.12371
Ivanova, D., Vita, G., Steen-Olsen, K., Stadler, K., Melo, P., Wood, R., Hertwich, E., 2017. Mapping the Carbon Footprint of EU Regions. Environmental Research Letters 12. https://doi.org/10.1088/1748-9326/aa6da9
Jackson, T., Papathanasopoulou, E., 2008. Luxury or ‘lock-in’? An exploration of unsustainable consumption in the UK: 1968 to 2000. Ecological Economics 68, 80–95. https://doi.org/10.1016/j.ecolecon.2008.01.026
Jakob, M., Marschinski, R., 2013. Interpreting Trade-Related CO2 Emission Transfers. Nature Climate Change 3, 19–23. https://doi.org/10.1038/nclimate1630
Jakob, M., Marschinski, R., Hübler, M., 2013. Between a Rock and a Hard Place: A Trade-Theory Analysis of Leakage Under Production- and Consumption-Based Policies. Environmental and Resource Economics 56, 47–72. https://doi.org/10.1007/s10640-013-9638-y
Jones, A., Woodward, L., Elm Farm Research Centre, 2002. Eating Oil. Elm Farm Research Centre.
Jones, C.M., Kammen, D.M., 2014. Spatial Distribution of US Household Carbon Footprints reveals Suburbanisation undermines Greenhouse Gas Benefits of Urban Population Density. Environmental Science & Technology 48, 895–902. https://doi.org/dx.doi.org/10.1021/es4034364
Jones, C.M., Kammen, D.M., 2011. Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities. Environmental Science & Technology 45, 4088–95. https://doi.org/10.1021/es102221h
Kanemoto, K., Moran, D., Lenzen, M., Geschke, A., 2014. International trade undermines national emission reduction targets: New evidence from air pollution. Global Environmental Change 24, 52–59. https://doi.org/10.1016/j.gloenvcha.2013.09.008
Kettner-Marx, C., Kirchner, M., Kletzan-Slamanig, D., Köppl, A., Meyer, I., Sinabell, F., Sommer, M., 2018. Schlüsselindikatoren zu Klimawandel und Energiewirtschaft 2016. Sonderthema: CO2-Steuern für Österreich, in: WIFO-Monatsberichte. WIFO, Wien, pp. 507–524.
Kissinger, M., 2012. International Trade Related Food Miles – The Case of Canada. Food Policy 37, 171–178. https://doi.org/10.1016/j.foodpol.2012.01.002
Larsen, H.N., Hertwich, E.G., 2011. Analyzing the Carbon Footprint from Public Services provided by Counties. Journal of Cleaner Production 19, 1975–1981. https://doi.org/10.1016/j.jclepro.2011.06.014
Lenzen, M., Dey, C., Foran, B., 2004. Energy Requirements of Sydney Households. Ecological Economics 49, 375–399. https://doi.org/10.1016/j.ecolecon.2004.01.019

Lenzen, M., Kanemoto, K., Moran, D., Geschke, A., 2012. Mapping the Structure of the World Economy. Environ. Sci. Technol. 46, 8374–8381. https://doi.org/10.1021/es300171x
Lenzen, M., Murray, J., 2010. Conceptualising Environmental Responsibility. Ecological Economics 70, 261–270. https://doi.org/10.1016/j.ecolecon.2010.04.005
Lenzen, M., Murray, J., Sack, F., Wiedmann, T., 2007. Shared Producer and Consumer Responsibility — Theory and Practice. Ecological Economics 61, 27–42. https://doi.org/10.1016/j.ecolecon.2006.05.018
Lenzen, M., Wier, M., Cohen, C., Hayami, H., Pachauri, S., Schaeffer, R., 2006. A Comparative Multivariate Analysis of Household Energy Requirements in Australia, Brazil, Denmark, India and Japan. Energy 31, 181–207. https://doi.org/10.1016/j.energy.2005.01.009
Lenzen, M., Wood, R., Foran, B., 2008. Direct versus Embodied Energy – The Need for Urban Lifestyle Transitions, in: Urban Energy Transition. Elsevier, pp. 91–120. https://doi.org/10.1016/B978-0-08-045341-5.00004-9
Liu, H., Xi, Y., Guo, J., Li, X., 2010. Energy Embodied in the International Trade of China: An Energy Input–Output Analysis. Energy Policy 38, 3957–3964. https://doi.org/10.1016/j.enpol.2010.03.019
López, L.-A., Cadarso, M.-A., Gómez, N., Tobarra, M.-Á., 2015. Food Miles, Carbon Footprint and Global Value Chains for Spanish Agriculture: Assessing the Impact of a Carbon Border Tax. Journal of Cleaner Production 103, 423–436. https://doi.org/10.1016/j.jclepro.2015.01.039
Lorek, S., Spangenberg, J., 2014. Sustainable Consumption within a Sustainable Economy. Journal of Cleaner Production. https://doi.org/10.1016
Marcotullio, P.J., Sarzynski, A., Albrecht, J., Schulz, N., 2014. A Top-Down Regional Assessment of Urban Greenhouse Gas Emissions in Europe. Ambio 43, 957–968. https://doi.org/10.1007/s13280-013-0467-6
Max-Neef, M., 1989. Human Scale Development: An Option for the Future. Development Dialogue 1, 7–80.
Meng, B., Xue, J., Feng, K., Guan, D., Fu, X., 2013. China's Inter-Regional Spillover of Carbon Emissions and Domestic Supply Chains. Energy Policy 61, 1305–21. https://doi.org/10.1016/j.enpol.2013.05.108
Miehe, R., Scheumann, R., Jones, C.M., Kammen, D.M., Finkbeiner, M., 2016. Regional carbon footprints of households: a German case study. Environment, Development and Sustainability 18, 577–591. https://doi.org/10.1007/s10668-015-9649-7
Minx, J., Baiocchi, G., Wiedmann, T., Barrett, J., Creutzig, F., Feng, K., Förster, M., Pichler, P.-P., Weisz, H., Hubacek, K., 2013. Carbon Footprints of Cities and other Human Settlements in the UK. Environmentatl Research Letters 8, 1–10. https://doi.org/doi:10.1088/1748-9326/8/3/035039
Munksgaard, J., Wier, M., Lenzen, M., Dey, C., 2008. Using Input-Output Analysis to Measure the Environmental Pressure of Consumption at Different Spatial Levels. Journal of Industrial Ecology 9, 169–185. https://doi.org/10.1162/1088198054084699
Muñoz, P., Steininger, K.W., 2010. Austria's CO2 responsibility and the carbon content of its international trade. Ecological Economics 69, 2003–2019. https://doi.org/10.1016/j.ecolecon.2010.05.017
Newton, P., Meyer, D., 2012. The Determinants of Urban Resource Consumption. Environment and Behavior 44, 107–135. http://dx.doi.org/10.1177/0013916510390494
Niedertscheider, M., Haas, W., Görg, C., 2018. Austrian Climate Policies and GHG-emissions since 1990: What is the Role of Climate Policy Integration? Environmental Science & Policy 81, 10–17. https://doi.org/10.1016/j.envsci.2017.12.007
OECD, 2017. OECD Economic Surveys: Austria 2017, OECD Economic Surveys: Austria. OECD, Paris. https://doi.org/10.1787/eco_surveys-aut-2017-en
OECD, 2015. OECD Economic Surveys: Austria 2015, OECD Economic Surveys. OECD, Paris.
OECD, 2013. OECD Economic Surveys: Austria 2013, OECD Economic Surveys: Austria. OECD, Paris. https://doi.org/10.1787/eco_surveys-aut-2013-en
Ottelin, J., Heinonen, J., Junnila, S., 2017. Rebound Effects for reduced Car Ownership and Driving, in: Kristjánsdóttir, S. (Ed.), Nordic Experiences of Sustainable Planning: Policy and Practice, Urban Planning and Environment. Routledge, Abingdon, Oxon ; New York, NY.
Ottelin, J., Heinonen, J., Junnila, S., 2015. New Energy Efficient Housing Has Reduced Carbon Footprints in Outer but Not in Inner Urban Areas. Environmental Science & Technology 49, 9574–9583. https://doi.org/10.1021/acs.est.5b02140
Peters, G.P., Minx, J.C., Weber, C.L., Edenhofer, O., 2011. Growth in Emission Transfers via International Trade from 1990 to 2008. Proceedings of the National Academy of Sciences 108, 8903–8908. https://doi.org/10.1073/pnas.1006388108
Pirog, R.S., Benjamin, A., 2005. Calculating Food Miles for a Multiple Ingredient Food Product. Leopold Center Pubs and Papers.
Pirog, R.S., Benjamin, A., 2003. Checking the Food Odometer: Comparing Food Miles for Local versus Conventional Produce Sales to Iowa Institutions. Leopold Center Pubs and Papers.
Pirog, R.S., Van Pelt, T., Enshayan, K., Cook, E., 2001. Food, Fuel, and Freeways: An Iowa Perspective on how far Food Travels, Fuel Usage, and Greenhouse Gas Emissions. Leopold Center Pubs and Papers.

Räty, R., Carlsson-Kanyama, A., 2010. Energy Consumption by Gender in some European Countries. Energy Policy 38, 646–649. https://doi.org/10.1016/j.enpol.2009.08.010
Reinders, A.H.M.E., Vringer, K., Blok, K., 2003. The Direct and Indirect Energy Requirement of Households in the European Union. Energy Policy 31, 139–153. https://doi.org/10.1016/S0301-4215(02)00019-8
Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K., Meinshausen, M., 2016. Paris Agreement Climate Proposals need a Boost to keep Warming well below 2 °C. Nature 534, 631–639. https://doi.org/10.1038/nature18307
Sanne, C., 2002. Willing Consumers - Or Locked-in? Policies for a Sustainable Consumption. Ecological Economics 42, 273–287. https://doi.org/10.1016/S0921-8009(02)00086-1
Shigetomi, Y., Nansai, K., Kagawa, S., Tohno, S., 2014. Changes in the Carbon Footprint of Japanese Households in an Aging Society. Environmental Science & Technology 48, 6069–6080. https://doi.org/10.1021/es404939d
Steen-Olsen, K., Wood, R., Hertwich, E.G., 2016. The Carbon Footprint of Norwegian Household Consumption 1999-2012. Journal of Industrial Ecology 20, 582–592. https://doi.org/10.1111/jiec.12405
Steininger, K., Lininger, C., Droege, S., Roser, D., Tomlinson, L., Meyer, L., 2014. Justice and Cost Effectiveness of Consumption-Based versus Production-Based Approaches in the Case of Unilateral Climate Policies. Global Environmental Change 24, 75–87. https://doi.org/10.1016/j.gloenvcha.2013.10.005
Tukker, A., Cohen, M.J., Hubacek, K., Mont, O., 2010. The Impacts of Household Consumption and Options for Change. Journal of Industrial Ecology 14, 13–30. https://doi.org/10.1111/j.1530-9290.2009.00208.x
Turrión-Prats, J., Duro, J.A., 2017. Determinants of Territorial Seasonality: A Case Study for Spanish Tourist Municipalities. Tourism Analysis 22, 583–588. https://doi.org/10.3727/108354217X15023805737701
UNEP, 2011. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication - A Synthesis for Policy Makers,.
UNFCCC, (United Nations Framework Convention on Climate Change), 2015. Paris Agreement.
Usubiaga, A., Acosta-Fernández, J., 2015. Carbon Emission Accounting in MRIO Models: The Territory vs. the Residence Principle. Economic Systems Research 27, 458–477. https://doi.org/10.1080/09535314.2015.1049126
Waye, V.C., 2008. Carbon Footprints, Food Miles and the Australian Wine Industry. Melbourne Journal of International Law 9. https://doi.org/10.2139/ssrn.2354830
Weber, C.L., Matthews, H.S., 2008. Food-Miles and the Relative Climate Impacts of Food Choices in the United States. Environmental Science & Technology 42, 3508–3513. https://doi.org/10.1021/es702969f
Wiedenhofer, D., 2011. Spatial and Socio-Economic Drivers of Direct and Indirect Household Energy Consumption in Australia. Social Ecology Working Paper 133.
Wiedenhofer, D., Guan, D., Liu, Z., Meng, J., Zhang, N., Wei, Y.-M., 2016. Unequal Household Carbon Footprints in China. Nature Climate Change. https://doi.org/10.1038/NCLIMATE3165
Wiedenhofer, D., Lenzen, M., Steinberger, J.K., 2013. Energy Requirements of Consumption: Urban Form, Climatic and Socio-Economic Factors, Rebounds and their Policy Implications. Energy Policy 63, 696–707. https://doi.org/10.1016/j.enpol.2013.07.035
Wiedmann, T.O., Schandl, H., Lenzen, M., Moran, D., Su, S., West, J., Kanemoto, K., 2013. The Material Footprint of Nations - Proceedings to the National Academy of Sciences. PNAS 112, 6271–6276.
Wier, M., Lenzen, M., Munksgaard, J., Smed, S., 2001. Effects of Household Consumption Patterns on CO2 Requirements. Economic Systems Research 13, 259–274. https://doi.org/10.1080/09537320120070149
Wilson, J., Tyedmers, P., Spinney, J.E.L., 2013. An Exploration of the Relationship between Socioeconomic and Well-being Variables and Household Greenhouse Gas Emissions. Journal of Industrial Ecology 17, 880–91. https://doi.org/DOI: 10.1111/jiec.12057
Zhang, C., Anadon, L.D., 2014. A Multi-Regional Input–Output Analysis of Domestic Virtual Water Trade and Provincial Water Footprint in China. Ecological Economics 100, 159–172. https://doi.org/10.1016/j.ecolecon.2014.02.006
Zhou, X., Imura, H., 2011. How does Consumer Behavior influence Regional Ecological Footprints? An Empirical Analysis for Chinese Regions based on the Multi-Region Input–Output Model. Ecological Economics 71, 171–179. https://doi.org/10.1016/j.ecolecon.2011.08.026