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Analysis

GHG Emissions and the Rural-Urban Divide. A Carbon Footprint Analysis Based on the German Official Income and Expenditure Survey☆

Bernhard Gill*, Simon Moeller

Institute of Sociology, Ludwig-Maximilians-Universitaet, Konradstrasse 6, D-80801 Munich, Germany

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ABSTRACT

Will climate change be mitigated automatically by ongoing processes of urbanization as proposed by the "dense cities" hypothesis? Our answer is based on the German official income and expenditure survey (EVS) of 2013, which allow us to disaggregate total household expenditures into 44 consumer good categories (COICOP) and their respective GHG intensities. Results show that the density effect of cities saves some greenhouse gas (GHG) emissions in Germany, but singularisation of households, higher incomes and greater consumption opportunities in cities work in the opposite direction. Thus, smaller and larger municipalities are more or less on par with each other in terms of per capita emissions. Rural households are found to be more affected by environmental taxes which are imposed on direct rather than on indirect energy use in the course of German "Energiewende" policy reform. This is discussed in the article as a rural-urban social equity problem.

1. Introduction

On a per capita basis, it may be that city dwellers produce less carbon emissions than their suburban peers, since they live in smaller apartments and commute smaller distances. For that reason, cities have been praised recently in popular accounts as ecological salvation (e.g. Glaeser, 2011b). While it sounds plausible that cities may save GHG emissions on a per capita base as due to their density, we ask: how strong is this effect really? And what about counterbalancing effects such as higher incomes which usually come along with urbanization (Poumanyvong and Kaneko, 2010)?

These questions are addressed in a burgeoning literature which has analysed the rural-urban carbon footprint divide in many countries and with different methods (for an overview see Schubert and Gill, 2015). For Germany, as far as we are aware, there have been no studies conducted on this issue. This is surprising given that the German government has established an ambitious energy transition program to withdraw from the use of fossil fuels as well as from atomic energy and to reduce GHG emissions by 80% until the year 2050 (Strunz, 2014). This "Energiewende" program, which in many parts of the world is observed as a challenging transition, involves different forms of taxation on energy use, mainly for private households, while energy intensive industries are considerably less burdened out of fear that they may lose their edge in global competition (Ekins et al., 2011; Habla and Roeder, 2013). As far as the density hypothesis is true, this would imply that rural households consume more household energy and gasoline and therefore are hit harder by environmental taxes than city dwellers. This distributional equity issue may jeopardize the up to now rather strong support for the environmental reforms in relevant parts of the German population.

To address these questions, we have based our analysis on the most current German official income and expenditure survey (EVS – collected in 2013) which is generally used to study the welfare impacts of economic change and policy reform. Our decomposition of consumption categories in the EVS shows that direct GHG emissions from private household and private transport energy expenditures are mainly determined by apartment size and car ownership, which show considerable urban-rural variations. At 43%, they represent a major share of total emissions and are affected directly by environmental taxes on energy prices, whereas 52% are indirect emissions from consumer goods and overhead emissions for capital investment, which are less impacted by taxation. The remaining 5% are attributed to government expenditures. The indirect emissions are mainly driven by available income which tends to be higher in cities, particularly in cities larger than 500,000 inhabitants.

This article contributes to the existing body of knowledge in three

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* Corresponding author.
E-mail address: Bernhard.Gill@lmu.muenchen.de (B. Gill).

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specific ways. First, being based on the carbon footprint method of consumer goods, it tests the density hypothesis for Germany (cf. Schubert and Gill, 2015). Secondly, in contrast to other carbon footprint studies, our article looks in closer detail at settlement patterns in conjunction with household composition, income effects and consumption opportunities, which may counterbalance the savings from density. Thirdly, by combining social and environmental data, particularly income elasticities and carbon intensities, the paper takes a much closer look at the social implications of environmental policies than has been done in many other carbon footprint studies.

The remainder of the article is divided into five sections. In the successive part, it builds on existing literature to derive testable assumptions; in the third part the data used and methods applied are described. Results are presented in part four and are discussed in part five. In the concluding section, we summarize the results and discuss possible policy recommendations.

2. Theory: GHG Emissions and Urban Settlement Patterns

In recent years the consequences of urban living for the environment have attracted increased attention in environmental research. Studies find that cities exert disproportionately high environmental pressure in terms of waste and emissions in relation to their spatial extension. When compared to a per capita basis, however, this picture might change (Dodman, 2009; Hoornweg et al., 2011a). The environmental advantages of cities in per capita terms have been subsumed under the “compact” or “density effect” hypothesis. But to what extent do GHG emissions depend on urban or rural settlement patterns and which causal mechanisms have to be taken into account? The discussion of existing literature and the derivation of our assumptions is divided into three subsections: density effects, which should result in carbon savings in the larger municipalities (Section 2.1); countervailing effects such as lower household size, higher incomes, and more consumption opportunities in cities (Section 2.2); and the specific vulnerability of rural households for higher energy prices (Section 2.3).

2.1. Density Effects Reduce Direct Per Capita GHG Emissions

The density effect refers to the benefits which accrue as a consequence of densely populated areas with a large share of high-rise, compact apartment living (Norman et al., 2006), shorter transport distances and more developed public transport (Rau and Vega, 2012; Anderson et al., 1996; Kenworthy and Laube, 1999). Several studies demonstrate the existence of per capita emission reductions in high-density urban cores due to savings in domestic energy consumption and transport services (Hoornweg et al., 2011b; Schubert et al., 2013). More compact building structures reduce the surface-area-to-volume ratio, and with it the loss of energy (Glaeser, 2011b). Similarly, network infrastructures like public transport and district heating, which are only cost-efficient in high-density urban areas, reduce carbon footprints by providing substitutes to private car use or more carbon-intensive fuels for heating (Dodman, 2009; Poumanyvong and Kaneko, 2010). This is especially the case where dependency on private transport in suburban and rural areas puts pressure on per capita emissions and, therefore, is one of the main determinants in carbon footprint analysis (VandeWeghe and Kennedy, 2007). By concentrating on direct emissions, the “dense cities” literature places emphasis on the benefits of urban compactness and the accompanying land use patterns which are characterised by economies of scale in building materials and transport options (Bettencourt et al., 2007). However, many studies which confirm the density effect hypothesis do not account for smaller household sizes, higher incomes and more consumption opportunities in cities. These potentially countervailing mechanisms are sketched out in the next subsection.

2.2. Countervailing Effects: Higher Incomes, Smaller Households, More Consumption Opportunities

It is a long-standing observation that urban labour markets allow for greater division of labour, higher productivity and, hence, more competitive wages (Puga, 2010). These characteristics are subsumed in economic research under the heading of agglomeration economies (Krugman, 1991; Glaeser et al., 2001; Rosenthal and Strange, 2004). Larger incomes in cities may increase consumption and therefore the emission of GHG elsewhere in the production chain that are then to be accounted for as “indirect emissions” — in contrast to the “direct emissions” from household production which usually include the GHG emissions embodied in fuels for domestic energy and private transport (Munksgaard et al., 2000).

However, larger incomes earned in cities are not necessarily spent there. If commuting is easy and comfortable, people may live in smaller municipalities at some distance from the cities' centre, an effect called suburbanisation (Siedentop, 2008 gives a comprehensive review for Germany). Wealthier people may specifically prefer a suburban way of living which offers more single-family residence opportunities. Since in consumer surveys incomes are attributed not to the place where they are generated but to the households' places of residence, under conditions of stronger suburbanisation we may expect higher incomes in wealthy suburbs and not necessarily in the cities themselves. This is especially true in more densely populated regions or countries, as smaller distances and a more highly developed road system may facilitate commuting, whereas in sparsely populated regions distances are usually longer and the road system less convenient (Kenworthy and Laube, 1999). We therefore expect an income advantage of cities over the countryside in thinly populated spaces while the opposite tendency should be observed in more densely populated regions.

In suburbs or rural communities we usually find larger families. Individualisation and singularisation mainly blossom in urban milieus. As a consequence, smaller households are prevalent there, a long standing observation of urban research (Wirth, 1938; Alonso, 1964; Becker, 1981; Glaeser, 2011a). Yet, per capita living costs are higher for smaller households (Hagenaars et al., 1994). This scale effect on the household level is usually accounted for by assigning different weights to household members (e.g. OECD equivalence scale). Smaller households are burdened with higher production costs since many tools and installations are needed only once per household. As a result, smaller households may shift a larger part of their available income to consumption expenditures and/or spend it on more carbon-intensive goods such as heating fuels. Therefore, we expect higher per capita emissions in smaller households (Gough et al., 2011; Underwood and Zahran, 2015; Schubert et al., 2013).

Additionally, the urban context could allow for more attractive consumption opportunities. Some of the literature exploring this suggestion points to an increased footprint in cities (Heinonen et al., 2013a). Thus, beyond increased buying power, agglomeration is also likely to change consumption in relation to overall lifestyle patterns (Glaeser et al., 2001; Heinonen et al., 2013b). More sophisticated consumption opportunities in cities could imply that more of the (higher) disposable income is spent and therefore less money put aside for “savings and private insurances”. Furthermore, expenses may also shift towards more carbon-intensive goods and services. For example, nearby airports may seduce urban dwellers to travel long distances more frequently (Lenzen et al., 2004; Holden and Norland, 2005). On the other hand, higher apartment rents (per square metre) absorb some of the disposable income and reduce its otherwise possible expenditure on more carbon intensive goods. In balance, we expect spending to be more carbon-intensive in cities than in rural areas.

2.3. Regressive Impact of Rising Energy Prices on Rural Households

Domestic energy is usually seen as a basic need with low income