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Analysis

Relationship between urbanization, direct and indirect greenhouse gas emissions, and expenditures: A multivariate analysis

Sanna Ala-Mantila *, Jukka Heinonen, Seppo Junnila

Aalto University School of Engineering, Department of Real Estate, Planning and Geoinformatics, P.O. Box 15800, FI-00076 Aalto, Finland

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A B S T R A C T

In this paper, we analyze the relationships between Finnish household types and their consumption-based carbon footprints. We calculate footprints by combining expenditure data with life-cycle greenhouse gas emission intensities derived from an environmentally extended input–output model. By applying regression analysis, we explore the effects of expenditure, urbanity, and household size on total, direct, and indirect emissions. The separate analyses for direct and indirect GHGs provide insights, not previously found in the literature, on the relationship between urbanity and carbon footprints. Holding expenditure constant, a rural lifestyle seems to be related to the highest GHG emissions. However, keeping in mind that the absolute amount of indirect emissions is major to direct emissions from home energy and private driving, the less prominent or even reversed relationship between indirect emissions and urbanity is also worth noting. The existence of household size scale effects depends whether direct or indirect GHGs are explained. We demonstrate that in order to gain a comprehensive understanding of mitigation policies and their effects, not only the averages but the various patterns of direct and direct emissions must be kept in mind. This paper complements the earlier carbon footprint assessments from the same authors by providing a comprehensive statistical analysis.

1. Introduction

1.1. Household Consumption in the Context of Global Climate Change

Environmental issues have played a role in economics since the times of Malthus and Ricardo. The environmental Kuznets curve (EKC) (e.g., Grossman and Krueger, 1991, 1995) remains the best-known hypothesis about the relationship between environment and income. The fiercely debated EKC claims that the state of the environment evolves as a function of per capita income, so that at low levels of income, the state of the environment deteriorates due to the growing demand of natural resources; but after reaching a certain level of income and environment delink resulting from structural economic change, it increased the demand of less environmentally harmful services, technological development, or increased environmental awareness (see Panayotou, 1993; Roca, 2003; Stern, 2004). In our view, EKC's inverted U-shape hypothesis is in many respects identical with the ever-mainstreaming concept of green growth. OECD (2011, 9) defines green growth as "fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies." Hence both the right-hand side of the environmental Kuznets curve and the concept of green growth seem to be based on the simultaneous continuation of economic growth and a reduction in the environmental burden. However, at least when analyzing environmental indicators of a profoundly global nature (such as greenhouse gas (GHG) emissions), sufficient empirical evidence of such a relationship is yet to be found (Azomahou et al., 2006; Holtz-Eakin and Selden, 1995; Stern, 2004). Hence, concentrating on resource-efficiency innovations and other ideas inspired by theories of ecological modernization (see Mol and Spaargaren, 2000) is necessary but not adequate in combating all environmental problems, namely global climate change. Along with many others, we believe that multiple levels (including the microeconomic level of households and their consumption) must be addressed, and a re-orientation of mitigation policies to start at the emissions driver, not the emission source, may provide new possibilities for combating climate change (Lenzen and Murray, 2010; Peters, 2010).

The lifestyles and consumption habits of especially those living in highly developed countries are in many respects unsustainable, and the paradigm of ever-increasing material consumption has been questioned (Jackson, 2005, 2009; WWF, 2012). Furthermore, approximately one-fifth of global carbon dioxide emissions are traded internationally, from developing or emerging countries to the consumers in developed markets (Davis and Caldeira, 2010, 5688; Peters and Hertwich, 2008, 1403). The consumption-intensiveness of the most affluent lifestyles has also been discussed at the city level (e.g., Dodman,

* Corresponding author. Tel.: +358 503088386.
E-mail address: sanna.ala-mantila@aalto.fi (S. Ala-Mantila).

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2009; Heinonen and Junnila, 2011a–c; Ramaswami et al., 2008; Schulz, 2010). The emissions embodied in international trade have inspired many to question the traditional production- or territorial-based allocation of emissions, and arguments in favor of a consumption-based (Peters, 2008; Wiedmann, 2009a, 211–212) or income-based accounting of emissions have been made (Marques et al., 2012). Accordingly, it has been argued that the production-based environmental Kuznets curves would ignore the existence of international trade and therefore the EKC findings lack a holistic picture of overall environmental improvements (e.g., Cole, 2004; Wagner, 2010).

Consumption's negative externalities are increasingly present also in political agendas: for example, the European Commission has set targets for its member states to reduce emissions not accounted for by the Kyoto protocol (EC, 2011), and a program for sustainable consumption and production was included in the Rio + 20 outcome (UN, 2012a). However, emissions outside of Kyoto (such as those occurring as a consequence of private consumption) are difficult to address; and without adequate empirical information, policies aimed at sustainable consumption are likely to be vague and idealistic (Ferrer-I-Carbonell and van den Bergh, 2004, 368). Furthermore, understanding the environmental effects of consumption choices of different types of households has been seen as being essential in assessing the welfare and income distribution effects of consumption-based tax reforms (e.g., Baranzini et al., 2000). Likewise, Marin et al. (2012, 72) highlight that concentrating on final consumption emphasizes the consumer's broad responsibility, and they propose that labeling, green taxes, or such policies on consumption could be combined with supply-side policies in a way that the revenues from the demand side could be targeted to product innovation and resource-efficiency endeavors.

1.2. Spatial and Socioeconomic Factors Explaining Environmental Impacts

Despite the rather extensive number of studies on embodied emissions, footprints, and sustainable consumption, awareness of the factors behind household consumption-based carbon footprints[1] is not comprehensive. In an affluent and open developed country such as Finland, the final domestic use is known to cause approximately one-half of the economy's climate impact (Hertwich and Peters, 2009; Seppälä et al., 2011). Even if this average figure is informative in itself, we argue that a more detailed picture of determinants of the final use's emissions is needed in order to create efficient mitigation policies. Furthermore, there is a relatively limited number of consumption-based GHG assessments within the country (Baiocchi et al., 2010; Heinonen and Junnila, 2011a,b,c; Heinonen et al., 2011; Kerkhof et al., 2009b; Ramaswami et al., 2008;).

The importance of lifestyles in explaining carbon dioxide emissions has been emphasized by Baiocchi et al. (2010). Several studies have discussed the topic of the relationship between urbanity and environmental impacts caused by households. Many authors have found urban living to be more energy-efficient than rural living (e.g., Lenzen et al., 2006; Shammin et al., 2010; Vringer and Blok, 1995). A number of studies that have analyzed the effects of density focus only on the direct environmental impacts caused by private driving or housing energy demand (Ewing and Rong, 2008; Glaeser and Kahn, 2010; Holden and Norland, 2005). However, in this paper, we argue that a more comprehensive perspective is needed, because the consumption of products and services also causes substantial amounts of indirect or embodied emissions (Bin and Dowlatabadi, 2005; Druckman and Jackson, 2009). Partly due to the emergence of this consumption-perspective, there has been in recent years been a heated debate on the role of different urban structures as greenhouse gas producers and urban dwellers as greenhouse gas consumers (Brown et al., 2009; Dodman, 2009). It has been argued that even if density offers some undeniable sustainability benefits, the consumption-intensive lifestyles of urban dwellers can undermine some of these benefits when indirect emissions are also taken into account (Heinonen and Junnila, 2011a,b,c; Heinonen et al., 2011). Besides the relationship between urbanity and environmental pressure, the effects of household size and related economies of scale have also been discussed by Lenzen et al. (2006).

Providing a step towards filling the gap, the purpose of this paper is to shed light on the structures of consumption-based carbon footprints by analyzing the direct and indirect parts of these footprints, both together and separately. We analyze the environmental effects of households and individuals within them by multivariate regression following the literature (Kerkhof et al., 2009a; Lenzen et al., 2006; Roca and Serrano, 2007; Shammin et al., 2010). Carbon footprints are calculated by combining greenhouse gas intensities derived from the environmentally extended input–output (EE I–O) model ENVIMAT (Seppälä et al., 2011) with expenditure data from the household budget survey. It has been broadly acknowledged that the combination of the two allows the assessment of the amount of greenhouse gases that consumption causes directly and indirectly (see reviews by Tukker and Jansen, 2006; Wiedmann, 2009a). The tradition dates back to the 1970s when the first study of direct and indirect energy consumption of U.S. households was done (Herendeen and Tanaka, 1976), and many have followed (Kerkhof et al., 2009a; Lenzen et al., 2006; Roca and Serrano, 2007; Shammin et al., 2010; Vringer and Blok, 1995; Weber and Matthews, 2008). In this paper, we analyze the footprints with multivariate regression models to study how they vary with the identified key variables: urbanity and household size.

We believe that our econometric approach, which takes into account all-important features of the sampling procedure in which the household consumption survey was collected, allows us to get accurate estimates and standard errors. As far as we are concerned, in the previous research these survey features of expenditure data were left untouched, and thus we believe that our econometric analysis is to some extent an improved one. We estimate the so-called expenditure elasticity of carbon for Finnish consumers. Furthermore, urbanity (which we argue to be the most interesting explanatory variable) is analyzed with a 4-step variable describing the urbanity of a municipality where the household lives. In addition, we do certain important modifications to the data to correct the bias deriving from the uncertainties related to the treatment of energy and housing expenditures.

Our article starts with the Material and Methods section, in which expenditure data along both methods utilized — environmentally extended input–output analysis and multivariate regression analysis — are described and their limitations were briefly addressed. Next, we present the results of the absolute analysis and the multivariate regressions. Finally, discussion and conclusions follow.

2. Material and Methods

2.1. Input Data: Household Consumption Survey

The data utilized in this article is the latest Finnish Household consumption survey from year 2006. This one period cross-section of data consists of 4007 households. Along with the actual detailed consumption expenditure data, classified according to the COICOP system, the data contains a wide array of background and income information for each household (Official Statistics of Finland, 2013b).

The household consumption survey is a sample survey using a single-stage stratified cluster sampling design. The final sample size is 4007 households. The original sample was about double the size with the magnitude of response being only 47.7%, a situation that can be referred to as under coverage. This non-response cannot be ignored,

[1] In this paper the term carbon footprint refers to household's consumption-based carbon footprint i.e. the carbon footprint that is derived from households' expenditure and in which both the direct and indirect emissions are allocated to the final consumer, despite the spatial origin of consumed products and services. This is drawn from the definitions of Lenzen et al. (2007) and Druckman and Jackson (2009). The consumption-based carbon footprint could also mean the consumption-based footprint of a nation (see e.g., Hertwich and Peters, 2009).