Ecological Economics 131 (2017) 152–165

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

A carbon footprint proportional to expenditure - A case for Norway?

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ARTICLE INFO

Article history:
Received 11 April 2015
Received in revised form 27 May 2016
Accepted 17 August 2016
Available online 8 September 2016

JEL classification:
C31
C67
D12
Q56

Keywords:
Carbon footprint
CO_2 emissions
Consumption
International trade
Decoupling

ABSTRACT

Motivated by the importance of consumption as an underlying driver of CO_2 emissions, we examine the link between consumption and CO_2 emissions for Norwegian households. The main goal is to investigate whether there is a decoupling of consumption expenditures and the environmental impact as we move up the income ladder. By combining a 2007 Norwegian consumer expenditure survey with emission coefficients from an environmental input-output model, reflecting emissions embodied in both domestically produced and imported goods and services, we calculate the per capita carbon footprint. The results from the analysis suggest that the per capita carbon footprint is directly proportional to expenditure with an estimated elasticity close to unity, implying no decoupling. The finding is partly driven by a near zero-emission power sector, which leads to comparatively low emissions embodied in domestically-produced goods and services.

1. Introduction

Climate change is a global threat, requiring a global solution. Yet, current and previous climate mitigation policies, such as the Kyoto protocol, regional treaties and national policies, fall short of being global. While the Paris agreement adopted in 2015 was the first-ever universal agreement on climate change involving all nations of the world, it contains no overall, global policy to combat climate change. Instead, it relies on a bottom-up approach, where nations have to submit so-called intended nationally determined contributions (INDCs). As for most climate mitigation policies, the policy goals are primarily stated in terms of a territorial-based accounting framework for GHG emissions. In a territorial-based accounting framework direct emissions generated by domestic production are included, while emissions embodied in imported goods and services are not.[1] As a consequence, the effect of a nation's policy could potentially be offset by international trade flows. Carbon leakage, i.e. the re-allocation of emission-intensive activities to regions with laxer constraints on GHG emissions, is a well-known, adverse effect of the territorial-based accounting framework.[2] As the framework is based on the geographical location of production, a country could in principle reduce its emissions by outsourcing emission-intensive activities, while maintaining the same level of consumption via imports. If we

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[1] More precisely, a territorial-based accounting framework records a nation's inventories as GHG emissions generated within the national territory, as well as offshore areas over which the country has jurisdiction (see e.g., Fleurbaey et al., 2014 p. 306). This implies that emissions generated as a consequence of domestic production are included - independent of whether the goods produced are exported or used for domestic consumption. At the same time emissions embodied in imports are excluded. Note that GHG emissions emitted in international territory, like international aviation and shipping, are not allocated to individual countries and are hence not included in the territorial-based calculations.

[2] As an example, studies of the effects of the Kyoto Protocol using Computable General Equilibrium models typically find carbon leakage to be in the range of 5–20% (Barker et al., 2007).

http://dx.doi.org/10.1016/j.ecolecon.2016.08.027
0921-8009/

want to reduce global emissions, it is therefore essential to address the relationship between emissions and consumption. Goods and services are ultimately produced for consumption purposes, and reallocating production without a decoupling[3] of emissions and consumption will not bring us any closer to a solution to the climate threat.

In recent years several researchers have advocated a stronger focus on consumption-based emissions when designing climate policies (see e.g., Baiocchi and Minx, 2010; Helm, 2012; Machado et al., 2001; Peters et al., 2012; Peters, 2008; Peters and Hertwich, 2006; Steinberger et al., 2012; Davis and Caldeira, 2010). In a consumption-based approach, the emissions related to exports are subtracted from the national inventories, while emissions embodied in imported goods are included. The result is an accounting framework where the consumption pattern in a country determines a country's emissions rather than the geographical location of the production sites. Emissions resulting from the consumption-based accounting framework are often referred to as the *carbon footprint*.[4]

Motivated by the importance of consumption as an underlying driver of CO_2 emissions, we investigate the consumption pattern and the associated environmental impact of Norwegian households, where we are particularly interested in (i) the distinction between domestically produced and imported goods, and (ii) how the environmental impact varies as we move up the income ladder. By combining a 2007 consumer expenditure survey (CES) with an environmental input-output model, we calculate the carbon footprint of Norwegian households, allowing us to compare direct and indirect emissions from consumption activities to the expenditure level of different households.[5]

We (and others before us) argue that the distinction between the territorial-based and the consumption-based accounting approach is particularly relevant for the case of Norway due to the country's characteristics (see e.g., Peters and Hertwich, 2006). First, Norway has high import levels, which are also increasing over time (SSB, 2012b, 2013), implying that a growing share of the carbon footprint is related to emissions embodied in imports. A narrow focus on territorial-based emissions could therefore be particularly misleading for the case of Norway. Second, Norway has one of the "greenest" power sectors in the world, owing to an extensive use of hydropower. As a consequence energy-intensive goods produced in Norway have relatively low embodied emissions, making it particularly important for the case of Norway to distinguish between the domestic energy mix and the one's of importing countries.[6] Lastly, the relationship between the carbon footprint and the expenditure level of Norwegian households will most likely be different from the average European households as many consumption categories, like heating, cooking, lighting and the use of electrical appliances, generate close to zero indirect emissions due to the green electricity mix.

Our main finding from the data analysis is that the 2007 carbon footprint of Norwegian households is directly proportional to expenditures, with an estimated elasticity close to unity. This suggests that there is no decoupling of emissions and expenditures as we move up the expenditure ladder, from low expenditure quintiles to higher expenditure quintiles. The close to linear relationship between the per capita expenditures and the per capita carbon footprint can partly be explained by the very low emissions from the Norwegian electricity production. Further, we find that high-expenditure households tend to consume relatively more imported goods than domestically produced goods, compared to low-expenditure households. While three previous studies looking at non-Norwegian households (Brazil, China and the UK) find weak or no evidence of a decoupling (Cohen et al., 2005; Golley and Meng, 2012, Druckman and Jackson, 2009), most of the existing literature tend to find that the environmental impact grows in a less than proportional way with income (see e.g., Lenzen et al., 2004; Girod and De Haan, 2010; Peters et al., 2006). We therefore provide new evidence on the relationship between the carbon footprint of households and expenditure or income levels that contrast some of the previous findings. In addition to generating new evidence for the case of Norway, we contribute to the broader literature on sustainable consumption and the role of international trade in at least four aspects.

First, we use non-aggregated household expenditure survey data to calculate the consumption-based emissions. While there are several cross country studies addressing the issue of carbon-leakage (see e.g., Barker et al., 2007), as well as the so-called environmental Kuznets curve[7] (see Stern, 2004 for an overview), we add to the literature on the environmental impact of consumption by exploiting within country variation.

Second, we contribute to the specific literature on how the carbon footprint of households vary with expenditures or income. While there are several studies exploiting household surveys to calculate the environmental impact in terms of energy use, only a few studies calculate the carbon footprint (see e.g., Peters et al., 2006; Weber and Matthews, 2008; Girod and De Haan, 2010; Druckman and Jackson, 2009; Golley and Meng, 2012). As most of the electricity used in Norwegian households, as well as in energy intensive industries, generate close to zero emissions, looking at the carbon footprint will give a very different picture than focusing on the energy use.

Third, we contribute to the carbon footprint literature by using a detailed environmental input-output table reflecting emissions from the global production chain. A shortcoming of some of the previous

[3] The term *decoupling* refers to a situation in which the growth rate of an environmental pressure is less than that of its driving force. A more detailed explanation of the term, as well as the distinction between absolute and relative decoupling, is provided in Section 2.

[4] While the term *carbon footprint* is widely used in both science and commerce, the meaning of the term vary both across academic studies and between public and academic use (Wiedmann and Minx, 2007). According to the fourth report from the Intergovernmental Panel on Climate Change (IPCC) "[t]here is no single accepted carbon footprinting methodology (…), nor is there one widely accepted definition of carbon footprint" (IPCC, 2007, p. 306). The report then gives an example of a definition from Peters (2010): "[t]he carbon footprint of a functional unit is the climate impact under a specific metric that considers all relevant emission sources, sinks and storage in both consumption and production within the specified spatial and temporal system boundary" (p. 245). Another definition is provided by the International Organization for Standardization (ISO), which define the carbon footprint of products (CFP) as "the sum of greenhouse gas emissions and removals in a product system, expressed as CO_2-equivalents and based on a life cycle assessment using the single impact category of climate change" (see http://www.iso.org/iso/home.html). Based on these definitions, the term carbon footprint used in our study only covers a subset of the environmental stressors resulting from consumption. First, we are only looking at CO_2 emissions, which is the most important of the man-made greenhouse gases. This means that other greenhouse gases, like methane (CH_4), nitrous oxide (N_2O) or fluorinated gas (F-gas), are not included. Second, we do not consider emissions resulting from (changes in) sinks and storage, like land use, land-use change and forestry. What we capture with our analysis is emissions resulting from the use of fossil fuels and process emissions. While our study has the limitation of not including the entire portfolio of climate impacts, it also has the benefit of clarity (see e.g., the discussion in Wiedmann and Minx, 2007). When comparing our estimate of the carbon footprint to estimates found in other studies, it is important to note which definition is used in the relevant study.

[5] The expenditure level can, to some degree, be seen as a proxy for income or how affluent a household is, in particular if the expenditure level is adjusted for the household structure. In our analysis we use expenditures, and not income, but adjust the expenditures for the family structure to arrive at a per capita estimate.

[6] While the Norwegian power sector is predominantly hydro-power based, international trade in electricity may lead to a different energy mix with corresponding higher embodied emissions. We discuss this issue and how it affects the calculations of the carbon footprint in Section 5.

[7] The environmental Kuznets curve hypothesizes that the relationship between emissions and income per capita has an inverted U shape, i.e. that emissions are increasing with income up until a certain "turning point", where emissions then start to decrease with income.