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Carbon and material footprints of a welfare state: Why and how governments should enhance green investments

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ABSTRACT

Sustainable development and climate change mitigation have become guiding policy principles in many welfare states. However, the traditional role of a welfare state is to guarantee the economic stability, jobs and welfare for its citizens. Sustainable development leans on the idea that we can have economic, social and environmental sustainability at the same time. This would require decoupling of economic growth from environmental degradation. Decoupling should be studied globally, because within nations, the economy can grow while local environmental impacts decrease, but at the same time, global environmental impacts may increase due to international trade. In this study, we examine the consumption-based carbon and material footprints of a Nordic welfare state, Finland. We focus on the environmental impacts of public spending, which has received little attention previously. In welfare states, the reallocation of public funds to services and individuals are at its core. In the study, we examine how this affects the carbon and material footprints of various income groups and household types. We find that the share of public services and investments is 19% of the carbon footprint and 38% of the material footprint per capita. Building of infrastructure plays a major role in composing the material footprint. We also find that the welfare state has important features that improve the carbon equity between the citizens. To achieve absolute decoupling, required to reduce environmental impacts caused by economic activities, we suggest policies promoting public and private green investments. In addition, increased carbon pricing would enhance green investments and drive environmental innovation.

1. Introduction

Sustainable development and climate change mitigation have become guiding policy principles in many welfare states. Welfare states are developing towards eco-states whose goal is to ensure that ecological boundaries are not crossed (Meadowcroft, 2005; While et al., 2010; Gough and Meadowcroft, 2011). However, environmental policies have to be reconciled with many other challenges that welfare states are facing today, such as increasing public debt, unemployment, social and economic polarisation and ageing population (Hellström and Kosonen, 2015). Conventional welfare states see economic growth as a prerequisite to tackle social and economic problems. Sustainable development, as coined by the famous Brundtland report (Brundtland et al., 1987), has been relatively easy for welfare states to adapt, since it does not question the objective of economic growth. However, economists, let alone ecologists, widely disagree on whether economic growth is actually needed to tackle environmental problems (Solow, 1973; Goldin and Winters, 1995; Ekins, 2002) or whether environmentally sustainable growth is an oxymoron (Meadows et al., 1972; Daly, 1990; Kallis, 2011). This has also led to arguments that there may be a contradiction between a conventional welfare state and an eco-state, since the finance of the public sector and high employment rate may be dependent upon environmentally unsustainable economic growth (see discussions by Meadowcroft (2005), and Bailey (2015)).

Sustainable development leans on the idea that we can have economic, social and environmental sustainability at the same time. It has been criticised for being more of an ideology than based on scientific knowledge (While et al., 2010). To materialise, sustainable development requires decoupling of economic growth from environmental burdens. Furthermore, we need to make a distinction between relative and absolute decoupling. Relative decoupling occurs when efficiency increases so that environmental impacts per unit of economic output decrease. To achieve absolute decoupling, the decrease of environmental impacts need to exceed the increase of output. There has been some scepticism about whether absolute decoupling is possible for greenhouse gas (GHG) emissions, for example (Jackson, 2011). Nonetheless, in 2014, global energy-related CO_2 emissions halted, although the global economy increased, which was perhaps the first evidence of

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absolute decoupling globally (Weiss, 2015; IEA, 2016). Moreover, advocates of green growth, meaning economic growth with decreasing environmental pressure, remind us that what we have done so far is only a fraction of what we could do to achieve green growth (Ekins, 2002). Green growth has been adopted to mainstream policy in the OECD and the EU.

One of the challenges of verifying absolute decoupling within nations is carbon leakage, or in more general terms, the relocation of any polluting action to other countries. Often decoupling is studied by comparing the GDP to the emissions caused within a country to demonstrate that the emissions are declining while the economy is growing. However, it is possible that, at the same time, the increased income is used to buy products from countries that have increasing environmental burdens in absolute terms (Peters and Hertwich, 2008; Giljum et al., 2015; Clement et al., 2017). As a solution to this accounting problem, consumption-based environmental assessments have gained popularity. Recently, Clarke et al. (2017) revealed, with Iceland as their case study, that even practically 100% decarbonised stationary energy production does not guarantee a low consumption-based carbon footprint for affluent countries with high import levels. Giljum et al. (2015) showed similar leakage effects for material consumption: even though domestic material consumption has decoupled from economic growth in some developed countries, the total raw material consumption (including materials embodied in imports) may increase at the same time.

Consumption-based carbon footprinting has been established as a complementary accounting method along with the more traditional territorial GHG accounting (Lenzen et al., 2007; Hertwich and Peters, 2009; Wiedmann, 2009; Minx et al., 2009; Ramaswami et al., 2011). The consumption-based method can be applied to assess other environmental impacts as well, such as energy and material requirements. While territorial accounting allocates the emissions to the geographical place of origin, the consumption-based method allocates the emissions to the final demand.

The purpose of the study is to depict the consumption-based carbon and material footprints of a Nordic welfare state, Finland. The focus of the study is on public spending, which has received little attention in previous studies. In addition, the study reveals how a welfare state improves carbon equity between different income groups. This is also an important and understudied feature of welfare states. Finally, the paper opens discussion on public policy on green investment based on the results of the study and previous literature.

Carbon footprints of households have been studied extensively using household budget surveys that are regularly collected in many countries (Druckman and Jackson, 2009; Wiedenhofer et al., 2013; Jones and Kammen, 2014; Heinonen et al., 2013a; 2013b; Nässén et al., 2015; Ottelin et al., 2015; Ala-Mantila et al., 2016). However, public spending is usually omitted from these assessments. This gives biased results if we wish to compare the households living in welfare states to households living in countries with less public spending. Furthermore, although wide-scoped international carbon and material footprint comparisons usually include public spending, they generally lump public expenditure together with household expenditure and public investments with private investments (Hertwich and Peters, 2009; Lenzen et al., 2012; Wiedmann et al., 2015). Wiedmann and Barrett (2011) have provided a more detailed analysis on the carbon footprint of UK Central Government. The study at hand gives a similarly detailed analysis on carbon and material footprints of total public spending in Finland. In addition, we analyse how the welfare state features affect carbon equity. While Wiedmann and Barret focus on public procurement policies, we participate in the broader discussion of the relationship between the welfare state and sustainable development.

In welfare states, the reallocation of public funds to services and individuals are at its core. The welfare state involves a transfer of funds from the state to the public services provided (i.e., healthcare, education, etc.) and direct income transfers to individuals. This is funded through taxation and usually includes a higher income tax for people with higher incomes. From an environmental perspective, this has implications on both the quantity and distribution of environmental pressure within the population (López et al., 2017). In the study, we examine how this affects the carbon and material footprints of various income groups and household types.

It should be noted that although the carbon and material footprints are presented side-by-side in the study, they are very different environmental indicators. Carbon footprint is an established indicator of global warming potential with a strong scientific basis. Material footprint, however, is more ambiguous. In the study, we use total material consumption (TMC) as the measure of material footprint. TMC is an environmental indicator that treats all natural resources similarly, and expresses them as total mass. It includes direct material input and hidden flows. Direct material input means natural resources that are directly used to produce goods and services. Hidden flows are transformed or moved natural resources that are not directly used by an economy, such as waste rock caused by mining, and materials needed to produce imported products that are not part of the product's mass (Seppälä et al., 2009).

The paper is structured as follows. Next, we present the research material and methods and then the results. The results section is followed by discussion. In the discussion section, we first interpret the empirical results of the study. Then we provide policy implications and discuss the broader theme of the welfare state and sustainable development. In addition, we discuss the main uncertainties of the study. The paper ends with conclusions.

2. Research material and methods

2.1. Research material

The main research material of the study is the Statistics Finland's Household Budget Survey 2012 and its additional part "Welfare services 2012" (Statistics Finland, 2012). In addition, we used the national accounts for year 2012 (Statistics Finland, 2017a) for filling the remaining gaps in public spending.

In the household budget survey that includes the welfare service addition, the public welfare services are allocated to the households using these services. The allocation is based on register information, interviews and administrative unit cost information. For example, the average unit costs of education are allocated to people who are registered in schools (high schools, vocational schools, universities etc. separately). The unit costs are vocation and faculty specific, but regional differences are not taken into account. The costs of basic education are allocated to all 7- to 15-year-olds according to the compulsory education age. Similarly, costs of health care and social services are allocated to households based on register information about the use of these services. The used unit costs for health and social services are national averages.

In the study, we used the national expenditure accounts 2012 that provide the gross domestic production (GDP) of Finland from the consumption perspective. The national expenditure accounts are divided into final consumption expenditure and investments, which are further divided by sector. The sectors include households, government and non-profit institutions serving households, and in the case of investments, also corporations. Government stands for both central and local government. Non-profit institutions include non-governmental organisations (NGOs) and churches. Investments, officially called gross fixed capital formation (GFCF), are divided into (1) dwellings, (2) other buildings and structures, (3) machinery, equipment and vehicles and (4) other GFCF, largely composed of intellectual property products, such as research and development (Statistics Finland, 2017a). The government's final consumption expenditure is divided into individual expenditure that serves households directly (Government individual consumption), and collective expenditure that includes collective

Table 1
Framework for carbon and material footprints of a welfare state (Finland) in the study.

National expenditure accounts (2012)		Carbon and material footprint models of the study		
	Million €	Source of expenditure data	Type of expenditure data	Accuracy of carbon and material footprint models
Final consumption expenditure				
Households	104,000	Household budget survey	Household specific	High
Government individual	32,900	Value of welfare services	Household specific	Medium
Government collective	15,800	National accounts	National average for all	Low
Non-profit institutions serving households	5,400	National accounts	National average for all	Very low
Gross fixed capital formation				
Government	8,100	National accounts	National average for all	Low
Non-profit institutions serving households	500	National accounts	National average for all	Very low
Corporations	23,500	GHG emissions and TMC included inherently in the purchaser price input-output tables		
Households	12,500	GHG emissions and TMC of purchase of vehicles and real estate included in the carbon and material footprint models		
Total	**202,700**			

services, such as public administration, maintenance of infrastructure, national defence and general safety and security services (Government collective consumption). Public welfare services belong to the government individual consumption.

2.2. Framework for assessing the carbon and material footprints

Table 1 outlines the framework for assessing the carbon and material footprints of the welfare state in the study. The framework is based on the national expenditure accounts 2012. The right-hand side of Table 1 describes how each of the final demand categories are included in the carbon and material footprint models of the study. The table gives the source and type of the expenditure data used in the study and describes the accuracy of the models. The most detailed data, and thus the most accurate footprint models, are provided for household expenditure and public welfare services. The accuracy of the data is estimated by the authors.

In the study, we chose to use the public welfare service addition of the household budget survey (Statistics Finland, 2012) to estimate government individual consumption expenditure instead of using the national expenditure accounts directly. The main benefit is that in the household budget survey, the welfare services are allocated to the households that are actually using the services. However, the downside is that there is some missing information. The economic value of public welfare services is ca. €3600 per capita according to the household budget survey. At the same time, the total value of government individual consumption expenditure is ca. €6100 per capita according to the national accounts. The difference is due to several reasons. First, the government individual consumption also includes some recreational and cultural services. Second, it also includes institutional care and social welfare for the disabled and elderly – and the residents of these institutions are largely missing from the household budget survey. Third, some health and social service-related information is sensitive, and thus there is likely to be some loss in the survey. The economic value of education per capita is almost the same in both data sources, but there is a discrepancy in health and social services.

To avoid significant underestimation, we assessed the GHG emissions and TMC of the remaining part of the government individual consumption expenditure by using the national accounts (national averages). We added this missing part of individual consumption to the government collective consumption to keep the household-specific data on public welfare services separated for detailed analyses.

2.3. EE IO analysis and hybrid life-cycle assessment

We assessed the carbon and material footprints of the welfare state with environmentally extended input-output (EE IO) analysis and hybrid life-cycle assessment (LCA). In general, EE IO analysis is an established method to assess the environmental pressure caused by economic activities (Lenzen et al., 2007; Wiedmann, 2009). It is based on the economic input-output tables of economies. The input-output tables consist of monetary transaction matrices that are extended with environmental data in EE IO analysis (Leontief, 1970). The main strength of the method is the comprehensiveness: the whole economy is included in the analysis. Another benefit is the simplicity of the method, which makes it quick to use after the model has been created (Junnila, 2006). The downside of EE IO analysis is roughness: aggregation error due to the aggregation of economic sectors and the inherent assumption of linearity of prices in the model, especially between large public and smaller private purchases. EE IO models can be made more accurate by integrating available process LCA data into the model. Such a method is called hybrid life-cycle assessment, and it aims at combining the best sides of EE IO analysis and process LCA (Suh et al., 2004). More recent comparisons of EE IO analysis and process-based methods can be found in Feng et al. (2011); Schoer et al. (2013); Hubacek and Feng (2016) and Lutter et al. (2016).

2.4. Carbon and material footprints of the study

In the study, we assessed material footprints with a pure EE IO model and carbon footprints with a hybrid LCA method. Both footprint models are based on the EE IO model of the Finnish economy, called ENVIMAT (Seppälä et al., 2009, 2011). The ENVIMAT model has been created by the Finnish Environment Institute. The purchaser price table of ENVIMAT includes 50 commodity categories, and we used it in the study to assess the carbon and material footprints of individual consumption. Individual consumption includes consumption expenditure of households and non-profit institutions and the government's individual consumption expenditure. The basic price table of ENVIMAT includes 150 product categories, and we used it to assess the carbon and material footprints of GFCF and the government's collective consumption. We used commodity category-specific inflation coefficients to match the expenditure data from the year 2012 with the ENVIMAT model from the year 2005. One common problem in single-region EE IO models is the domestic technology assumption, meaning that imports are treated as if they were produced with domestic technologies. Multiregional (MRIO) models have been created to overcome this problem (Wiedmann, 2009). ENVIMAT is not a full MRIO model, but imports have been taken into account by integrating life-cycle inventory (LCI) data from international databases into the model. This approach significantly reduces the uncertainty related to imports (Koskela et al., 2011). In Seppälä et al. (2011) the original developers of ENVIMAT report that they used LCI data from Ecoinvent database for the largest volumes of imported material flows and LCI data from Danish LCA Food

Database for food products. The direct material input of imports they applied from International Trade Statistics of Finnish Customs.

We describe the hybrid-LCA carbon footprint model of the study in detail in some of our previous studies on household carbon footprints (Ottelin et al., 2015; Ala-Mantila et al., 2016). To put it briefly, we used the hybrid LCA approach by integrating process LCA data on housing energy and car use into the EE IO model. The ENVIMAT model and thus the carbon footprint model of the study include CO_2, methane, nitrous oxide and fluorinated GHGs. LUCLUF sector is excluded.

We created the material footprint model for the purpose of the study. The ENVIMAT model includes the total material requirements (TMR) of economic activities. TMR consists of direct material inputs and hidden flows, such as waste rock in mining, logging residuals and leftover earth in construction. The data for domestic direct and hidden material flows in ENVIMAT is from Thule Institute's database on natural resource use in Finland (Seppälä et al., 2009). The data sources for the imported material flows are described above. TMR includes domestic consumption and exports. Generally, TMC can be derived from TMR by subtracting the exports. In the study, we used consumption-based material intensities provided by Seppälä et al. (2009) to calculate the TMC of final demand. We built the material footprint model for households similarly as we built the carbon footprint model by multiplying a household's expenditure by material intensities of products and services derived from the ENVIMAT model. However, we could not add the hybrid LCA elements into the material footprint model due to the lack of suitable process LCA data.

One special feature of both of our footprint models is that we have compensated the maintenance charges and rents in the household budget survey by using statistics on the financial statement from the housing companies provided by Statistics Finland (2017b). This way, we avoid biases caused by variation in rentals. The statistics give the average expenses of housing companies per square metre of living space. The statistics are building type and age specific. Since the household budget survey includes the same parameters of buildings (building type, age and living space) for each household, we get a more accurate estimate of GHG emissions and TMC per household. In the case of construction, we used a living space-based estimate: 0.7 CO_2-eq t/m^2 (Säynäjoki et al., 2017) and TMC 6.4 t/m^2. We estimated the TMC of building construction with the ENVIMAT model and total constructed floor space in Finland in 2005 (base year of the ENVIMAT model).

2.5. Allocation of welfare services and income transfers to households

In order to examine how welfare state features affect the carbon and material footprints of various income groups and household types, we first divided the population into six household types. Next, we divided each of these household types into three income classes so that every income group (low, middle, high) includes one third of the population. The income classes are household type specific. Table 2 presents the average income per capita, average age of the respondent and average household size of the studied groups. The category of young families represents families with one or more children under 7 years old.

We used the public welfare service addition of the household budget survey to allocate the GHG emissions and TMC caused by public welfare services to the households using these services. In addition, we wanted to examine how income transfers affect the distribution of environmental impacts between the studied groups. Thus, we calculated the part of household consumption that is covered with income transfers. The information on income transfers is provided in the household budget survey. We subtracted the paid income transfers from the received income transfers in order to avoid double counting.

Table 2
The household type categories and income classes of the study.

Household type	Income class	*Income €/year per capita*	Average age of the respondent	Average household size
Young adults (18-30 years)	low	9,600	23.2	1.3
	middle	17,400	25.3	1.4
	high	26,200	27.0	1.4
Adults (30-50 years)	low	15,800	40.6	1.4
	middle	27,100	39.4	1.4
	high	41,900	40.6	1.3
Adults (50-65 years)	low	16,300	59.9	1.5
	middle	25,900	58.4	1.7
	high	42,200	58.2	1.5
Seniors (> 65 years)	low	14,200	76.3	1.4
	middle	19,900	74.1	1.4
	high	34,800	72.3	1.5
Young families & single parents	low	9,400	37.8	3.9
	middle	15,300	38.5	3.4
	high	23,300	41.5	3.1
Other families with children	low	12,700	47.2	4.5
	middle	18,600	47.1	3.6
	high	29,600	50.5	3.5

3. Results

3.1. Overview

Public services and investments compose a notable share of the consumption-based carbon and material footprints in Finland. Fig. 1 illustrates the percentage shares of households, non-profit institutions, and public services and investments of the total monetary consumption and consumption-based carbon and material footprints in Finland in 2012. Table 3 displays the monetary consumption and carbon and material footprints per capita in more detail. In addition, Table 3 provides the GHG and material intensities for the studied final demand categories. Total monetary consumption was €33,000 per capita, total carbon footprint 12.3 CO_2-eq t per capita and total material footprint 41 t per capita. The share of government consumption expenditure and GFCF was 32% (€10,400) of the total monetary consumption, 19% (2.4 CO_2-eq t) of the carbon footprint and 38% (16 t) of the material footprint. The share of non-profit institutions serving households of total monetary consumption and environmental burdens was small (3–4%).

3.2. Material footprint

The material footprint (TMC) including public spending was 41 t per capita in Finland in 2012. For the sake of comparison, the material footprint without unused extraction of raw materials in Finland was 30 t in 2008 according to Wiedmann et al. (2015). Since Seppälä et al. (2009) estimate the share of unused extraction (hidden flows) to be about a quarter of TMC in Finland, the results seem quite comparable. In the study by Wiedmann et al., the material footprint of Finland was quite similar to other affluent European countries, except that the share of fossil fuels was higher – probably due to high use of fossil fuels for heating.

Construction of buildings and infrastructure play a major role in composing the material footprint. Household consumption on shelter (housing energy, maintenance and construction) composes 22%, and government GFCF 27%, of the total material footprint. The high share of government GFCF is mainly due to the construction of infrastructure

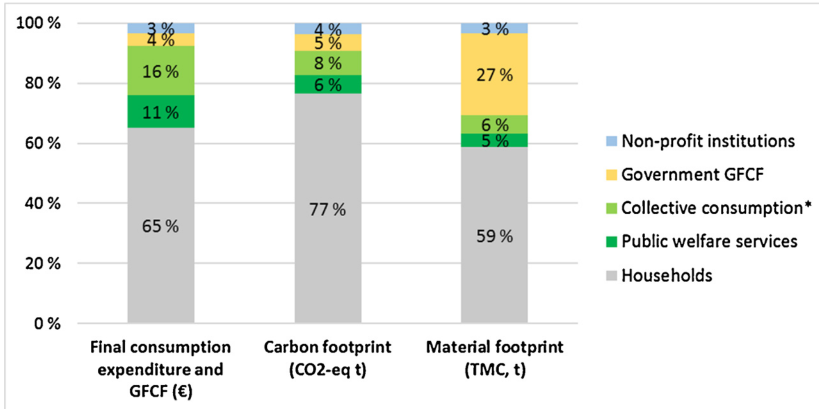

Fig. 1. Monetary consumption and consumption-based carbon and material footprints of Finland in 2012: Shares of public spending. *Collective consumption includes here the residue of public individual consumption that is not welfare services, see method section.

and related earth moving, which are responsible for approximately 80% of the TMC of government GFCF.

As explained in the introduction, TMC is an environmental indicator that treats all resources as equal and sums them up as total mass. Thus, it says very little about resource depletion, for example (Fang and Heijungs, 2014). However, the massive material footprint of the government GFCF particularly due to earth moving does indicate that the public sector is responsible for large land-use changes because of greenfield construction. The annual construction of infrastructure actually has a higher TMC than the annual construction of residential buildings in Finland. Thus, infrastructure should not be neglected when the environmental impacts of construction are assessed. The land-use changes due to the construction of infrastructure may have significant GHG implications as well. For example, forests are cut in order to build transport and energy networks. These impacts are generally excluded from carbon footprint assessments.

3.3. *Welfare services and carbon equity*

The carbon footprints of Finnish households have been studied extensively (Heinonen et al., 2011, 2013a, 2013b; Ala-Mantila et al., 2014, 2016; Ottelin et al., 2015, 2017, 2018). Thus, we focus here on the new findings of the study. As already noted in the overview above the share of public spending was 19% (2.4 CO_2-eq t) of the total carbon footprint. Here, we focus on a more gradual analysis of public welfare services, since the data allows us to examine them in more detail than other public expenditure. While government GFCF and collective consumption are difficult to allocate to specific households in any other way except equal shares, public welfare services can be allocated to the households actually using these services. Fig. 2 depicts how the addition of public welfare services affects the carbon footprints of different income groups and household types. In addition, in order to highlight how welfare states improve the carbon equity between different income groups, the part of household consumption that is covered with income transfers has been shaded with darker grey in the figure. The same figures for material footprints are presented in the Appendix A (Figs. A1 and A2). The material footprints follow the same pattern.

Table 4 presents how large share of carbon footprint is caused by the public welfare services and income transfers in different income quantiles. On average, the consumption covered by income transfers

Table 3
Final demand, carbon and material footprints and GHG and material intensities.

		€ per capita	CO_2-eq t per capita	TMC t per capita	CO2-eq kg/€	TMC kg/€
Public welfare services	Education	1,650	0.40	0.72	0.24	0.44
	Health	1,560	0.31	1.06	0.20	0.68
	Social services	390	0.06	0.12	0.15	0.31
	Total public welfare services	3600	**0.76**	**1.89**	**0.21**	**0.53**
Collective consumption*	Collective consumption	3,110	0.64	1.68	0.21	0.54
	Added individual consumption	2,300	0.34	0.84	0.15	0.37
	Total collective consumption	**5,410**	**0.98**	**2.52**	**0.18**	**0.47**
Government GFCF	Buildings and infrastructure	780	0.38	10.51	0.49	13.47
	Machinery and equipment	160	0.20	0.47	1.25	2.94
	Other GFCF	470	0.10	0.27	0.21	0.57
	Total government GFCF	**1,410**	**0.67**	**11.25**	**0.48**	**7.98**
Non-profit institutions	Consumption expenditure	1,000	0.43	1.02	0.43	1.02
	GFCF	90	0.03	0.32	0.33	3.56
	Total non-profit institutions	**1,090**	**0.46**	**1.35**	**0.42**	**1.23**
Households	Shelter	4,950	3.20	9.04	0.65	1.83
	Private vehicles	2,500	1.84	2.14	0.74	0.86
	Other travel	940	0.70	1.00	0.74	1.06
	Services	2,670	0.64	2.05	0.24	0.77
	Tangibles	3,090	1.38	4.18	0.45	1.35
	Food	2,600	1.67	5.77	0.64	2.22
	Total households	**21,470**	**9.43**	**24.19**	**0.44**	**1.13**
	Total all	**32,980**	**12.31**	**41.20**	**0.37**	**1.25**

*Collective consumption includes here the residue of public individual consumption that is not welfare services, see method section.

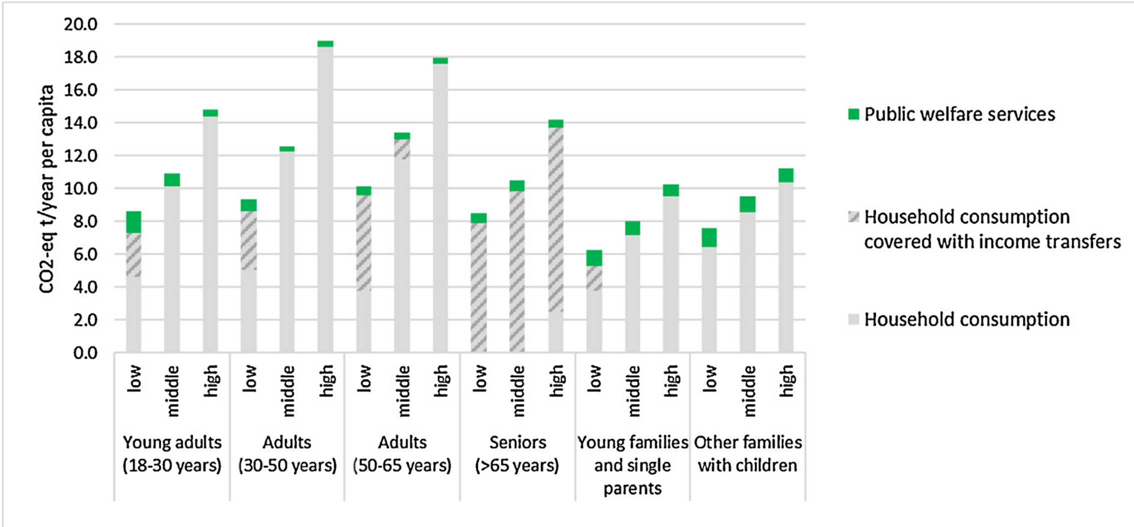

Fig. 2. The impact of public welfare services and income transfers on the household carbon footprints.

Table 4
The share of income transfers and public welfare services of total carbon footprint by income quantiles.

Income group	Income transfers	Public welfare services	Total CF (CO2-eq t)
Lowest 25%	28 %	10 %	9.5
Mid 50%	12 %	6 %	12.4
Highest 25%	−21 %	2 %	18.5

compose 12% and public welfare services 6% of total carbon footprint. Taxation is progressive in Finland, which allows the relatively high average share of income transfers. In the highest income quantile, the share of income transfers is negative because the group pays more income transfers than it receives.

Fig. 2 and Table 4 demonstrate the general pattern that carbon footprints increase with increasing income. However, welfare states improve carbon equity with two mechanisms: (1) the use of public welfare services tends to increase with decreasing income and (2) a significant share of household consumption is covered with income transfers in lower income groups and among pensioners. In countries with less welfare state features, the difference between various income groups is much harsher. For example Shammin and Bullard (2009) demonstrate that in US the highest income quantile has around four times as high carbon footprint as the lowest income quantile. Similarly, Wiedenhofer et al. (2017) reveal even larger differences in carbon footprints between urban rich and rural poor residents in China. Fig. 3 illustrates in more detail, which welfare services various households use, and how public welfare services are supplemented or substituted with private welfare services. The use of private welfare services is derived from the household budget survey. Recreational and cultural services are subsidised by the government, although mainly paid directly by households.

As Fig. 3 illustrates, the use of private services tends to increase with income, while the use of public welfare services generally decreases with income. Most strikingly, the use of public education services decreases with increasing income among young adults and families. This is quite natural, since students have lower income than those young adults who have already graduated and moved onto working life. Income correlates with age here (see Table 2). Education is predominantly a free-of-charge public service in Finland. In the case of families, also the number of children and children's age may affect the result. In other words, it may be that in lower-income families the

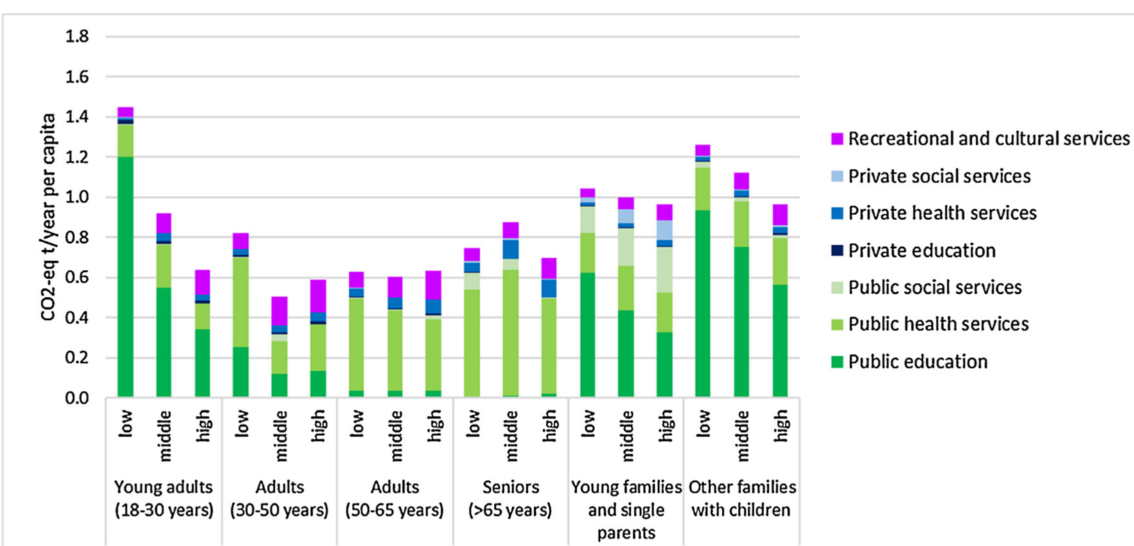

Fig. 3. The carbon footprint of public and private welfare services by household type and income group.

parents are more often still students, but it also seems that they have more school-aged children (see Table 2). Income per capita decreases with increasing household size (see Table 2). Private education plays only a minor role in Finland. Public health services are used quite equally in all income groups. When household types are compared, seniors use them most. The peak among low-income adults (30–50 years) suggests that health problems at a young age are likely to cause income losses, and/or that poverty increases health risks. Private health services are most popular among middle- and high-income seniors, but all groups use them to some extent. Social services are mainly childcare and domestic services for the elderly, which explains the high use among young families and seniors. Private childcare increases in popularity with increasing income. The use of recreational and cultural services increases with income but all groups use them at least to some extent.

4. Discussion

4.1. Discussion on the results of the study

The aim of the study was to examine how the addition of public spending affects the carbon footprints of welfare state citizens. Although the carbon footprints of households have been studied extensively, the studies are usually based on household budget surveys. As a general rule, these studies exclude public spending. At the same time, international carbon and material footprint comparisons often include public spending (Hertwich and Peters, 2009; Lenzen et al., 2012; Giljum et al., 2015; Wiedmann et al., 2015) but only at a very rough level, the focus being elsewhere.

The results of the study reveal that the contribution of public spending on total carbon and material footprints per capita is not negligible. Thus, studies on household carbon and material footprints in welfare states generally underestimate the environmental burdens caused by the citizens of these countries, compared to studies from countries with less public spending. This should be taken into account when comparing and applying the results of such studies, for example the recent studies by Ivanova et al. (2016, 2017).

Furthermore, the results demonstrate that while the addition of welfare services to household carbon footprints increases the carbon equity between various income groups, it does not change the general pattern that environmental burdens increase with increasing income. However, the joint effect of public welfare services and income transfers on carbon equity is tremendous, compared to countries without these welfare state features. For example, in US the highest income quantile has around four times as high carbon footprint as the lowest income quantile (Shammin and Bullard, 2009) and in China the difference between urban rich and rural poor is even harsher (Wiedenhofer et al., 2017). Hubacek et al. (2017) highlighted similar carbon inequalities globally. We found that in Finland the carbon footprint of the highest income quantile is less than double the carbon footprint of the lowest income quantile. From the perspective of environmental policy, welfare states can influence strongly the environmental impacts of public services and investments. These are directly organised or purchased by public organisations. For example in the EU, green public procurement policies are already in place (European Commission, 2008). The income transfers, on the other hand, are paid to the consumers, and the consumers can usually decide themselves what goods and services they purchase. These environmental impacts are more difficult to target.

4.2. Why and how governments should enhance green investments

The broader theme of the study is the relationship between the welfare state and sustainable development. We find it important to depict the total composition of consumption-based carbon and material footprints of a welfare state, since, in order to reduce the environmental burdens of the society, we need a comprehensive understanding of which economic activities drive the emissions and material requirements. The consumption-based accounting method, used in the study, lays bare the environmental pressure caused by our high living standards. Indirectly, it also captures the relationships between investments and public and private consumption. The following policy suggestions draw from previous literature and not only from the results of the study. In addition, they take into account the traditional role of the welfare state that is to guarantee the economic stability, jobs and welfare for its citizens.

One of the special features of consumption-based GHG assessment is that it captures the rebound effects of consumption. In general, rebound effect means the unintended consequences of climate change mitigation measures due to shifts in consumption (Lenzen and Dey, 2002; Hertwich, 2005; Druckman et al., 2011). Usually, rebound effects are considered as unwanted side effects. However, some studies have found evidence of desirable rebound effects (additional GHG reductions) related to investments (Mizobuchi, 2008; Nässén and Holmberg, 2009; Chitnis et al., 2013; Font Vivanco et al., 2014; Ottelin, 2016; Ottelin et al., 2017, 2018). In practice, the invested funds must be withdrawn from other purposes that would otherwise cause emissions. Nässén and Holmberg (2009) theorised the phenomenon and suggested that environmentally driven early adoption of new (costly) technologies might be a good strategy. Jackson (2011) suggested that ecological investments could be used at macro-economic level to achieve sustainability.

GDP, which despite its deficiencies, is one of the main welfare indicators that decision makers in welfare states follow, is actually indifferent about the nature of the economic activities it measures (Jackson, 2011). Thus, we could shift a part of economic activity from consumption to investments, without endangering the stability of economy. Investments into developing and introducing new clean technologies seem the most reliable way to achieve absolute decoupling, required to have economic growth without increasing environmental burdens. Statistics of the World Bank reveal that the share of investments of GDP has declined in the EU region (EU28) from around 30% in 1970 to 20% in 2015 (World Bank, 2017). The trend has been similar in many welfare states: Austria, Denmark, Finland, Germany, Italy, Netherlands, UK, and to some extent France and Sweden. Thus, we seem to have room to increase the share of investments again. What makes this approach problematic at the time being is that green investments are unlikely to be as profitable as traditional investments. As Jackson (2011) put it, ecological investments have different rates and periods of return from what we have learned to expect. Similarly, literature on environmental innovation has found that returns of investing in environmental innovation are very uncertain (Borghesi et al., 2015). The root of the problem is that the external environmental costs of economic activities are left for the society instead of demanding the companies and ultimately the consumers to pay them.

Green investments could be enhanced by introducing stronger environmental economic policies, such as carbon pricing. If GHG emissions had a higher price, it would increase the profitability of low-carbon and negative emission technologies (e.g. carbon capture and storage), which would speed up their development. Interestingly, research on the impact of government policy on environmental and clean innovations in the private sector has led to similar conclusions (Veugelers, 2012; Borghesi et al., 2015). Veugelers (2012) highlights that carbon pricing does not only reduce the consumption of dirty technologies, but is also an important incentive for the private sector to develop and adopt clean technologies. Another issue is that environmental innovations tend to benefit the general public instead of the investor (e.g. investing firm). According to Borghesi et al. (2015), this is one of the main reasons why firms generally have little or no incentive to perform environmental innovations unless environmental regulation induces them to do so.

A report by the World Bank (Kossoy et al., 2015) reveals that although there is an increasing amount of carbon pricing policies around the world, there is a high degree of variation in the price of carbon, and generally, the price is often too low to create a strong incentive for the private sector. Some firms have actually adopted internal carbon pricing as a strategic tool in order to gain a competitive edge in the low-carbon markets. Similarly, one could imagine that a country or a region with strong carbon pricing policies would be in the forefront in developing technologies that everybody will need eventually. Welfare states have one asset on this score: an existing large public sector and the taxes needed for its funding. What needs to be done in order to shift to an environmentally sustainable economy and speed up environmental innovation, is to shift the taxation away from services and goods – and labour – that have low GHG intensity to goods and services with high GHG intensity. This could be done without increasing the taxation overall. Although there is undoubtedly a lot of opposition from GHG-intensive economic sectors, there would also be a lot of winners in such a shift, including many service sectors, service-based economy in general, clean technology companies, design, research and development etc. (see Table 3). In general, we could describe such economy as striving for better with less.

Carbon pricing policies have one serious fault, however: they tend to affect the lowest income groups most, since basic goods, such as energy and food have a high GHG intensity (Druckman and Jackson, 2008; Shammin and Bullard, 2009; Wiedenhofer et al., 2013). Thus, new income transfer policies would be needed as well. In practice, this means that the price of energy and food would increase for all, but the low-income households could cover the increasing costs with the new income transfers. Thus, their carbon footprints would not necessarily decrease. The main GHG reductions would come from the changes in the consumption behaviour of middle- and high-income households. For example, flying would become less affordable for many, but at the same time, the price of low-carbon services, including ICT services and many recreational and welfare services, would decrease. Middle- and high-income households would have to reduce or restructure their consumption. Either way, the GHG emissions would decrease and carbon equity between various income classes increase.

While higher carbon taxes (or increasing carbon price in general) would redirect consumption to low-carbon services and goods, to enhance negative emission technologies (NETs), somebody would have to pay for taking carbon out from the atmosphere. Intuitively, this seems like a state's role. Part of the returns of carbon taxes could be used to support NET investments in the private sector, and directly to NET investments in the public sector. Otherwise, we may be locked in a situation where NETs are more expensive and even more carbon intensive in the construction or implementation phase than their competing technologies, even though during their whole lifecycle they would be superior.

4.3. Main limitations and uncertainties of the study

The main strength of the consumption-based accounting, used in the study, is its comprehensiveness. It includes all life-cycle GHG emissions and TMC, without double counting at any stage. However, the model is highly aggregated, and the assumptions of linearity and homogeneity of prices cause uncertainty. In addition, in the study, we used the value of welfare services for the household, instead of national accounts directly, to assess the carbon and material footprints of government individual consumption, which causes some inconsistency. Nonetheless, the chosen approach allowed us to analyse the use of these public services in more detail at household level.

Material footprints are less studied than carbon footprints, probably because of the weaker scientific basis. Material footprint, TMC in the study, treats all resources as equal and sums them up as total mass. This sort of approach has been criticised for not taking into account that the environmental impacts can be highly material specific (Steinberger et al., 2010; Fang and Heijungs, 2014; Steinmann et al., 2017). For example, Fang and Heijungs (2014) point out that such an indicator fails to address the scarcity of resources. They propose a resource depletion footprint instead, which would treat materials differently depending on their scarcity. We agree with these notions, but in the study, we had no possibility to use a more sophisticated indicator due to lack of appropriate data. The material footprint is still included in the study, because it gives some interesting insights into the environmental pressure of public spending, particularly public investments. In addition, material productivity is an important sustainability indicator at the EU and OECD. However, the results should be interpreted carefully, since the indicator has the obvious weakness described above.

5. Conclusions

The purpose of the study was to depict the consumption-based carbon and material footprints of a welfare state by focusing on public spending that has been neglected in previous literature. The aim was also to reveal, how welfare state features, such as public welfare services and income transfers, affect carbon equity. The broader theme of the study was the relationship between the welfare state and sustainable development, which is reflected in the policy implications of the study.

The main findings of the study are that the share of public spending of carbon and material footprints is not negligible, and welfare states significantly improve carbon equity between households. In the study, public spending composes 19% of the carbon footprint and 38% of the material footprint of welfare state citizens. Welfare states enhance carbon equity with two mechanisms: (1) the use of public welfare services tends to increase with decreasing income and (2) a significant share of consumption is covered with income transfers in lower income groups. The joint effect is tremendous compared to countries with less welfare state features.

The policy implications of the study take into account the traditional role of the welfare state that is to guarantee the economic and social wellbeing of its citizens. However, in order to achieve sustainable development, environmental burdens need to be decoupled from economic growth. Based on previous literature on consumption-based GHG emissions, green investments seem the most viable way to achieve absolute decoupling. Investments in new (costly) clean technologies do not only reduce the targeted emissions, but in addition, cause desirable rebound effects since they reduce the budget of other investments and consumption, and related GHG emissions (Mizobuchi, 2008; Nässén and Holmberg, 2009; Chitnis et al., 2013; Font Vivanco et al., 2014; Ottelin, 2016; Ottelin et al., 2017, 2018). However, in the current economic model the best clean technologies for the environment are not always profitable in economic terms. Thus, we need stronger environmental economic policies, such as carbon pricing, to enhance the development and implementation of clean technologies. Welfare states have one asset on this score: an existing large public sector and the taxes needed for its funding. Shifting the emphasis of the taxation on GHG intensive economic activities would drive the technology to the right direction. Without these drivers, low-carbon and carbon negative technologies are too expensive too long, and we have a limited timeframe to mitigate climate change.

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Appendix A

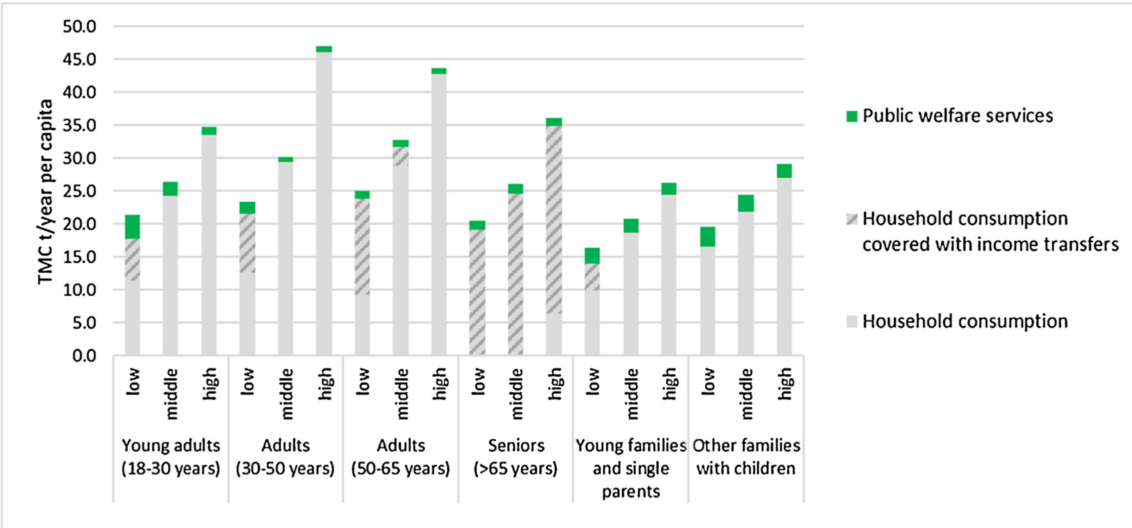

Fig. A1. The impact of public welfare services and income transfers on the material footprint of various income groups.

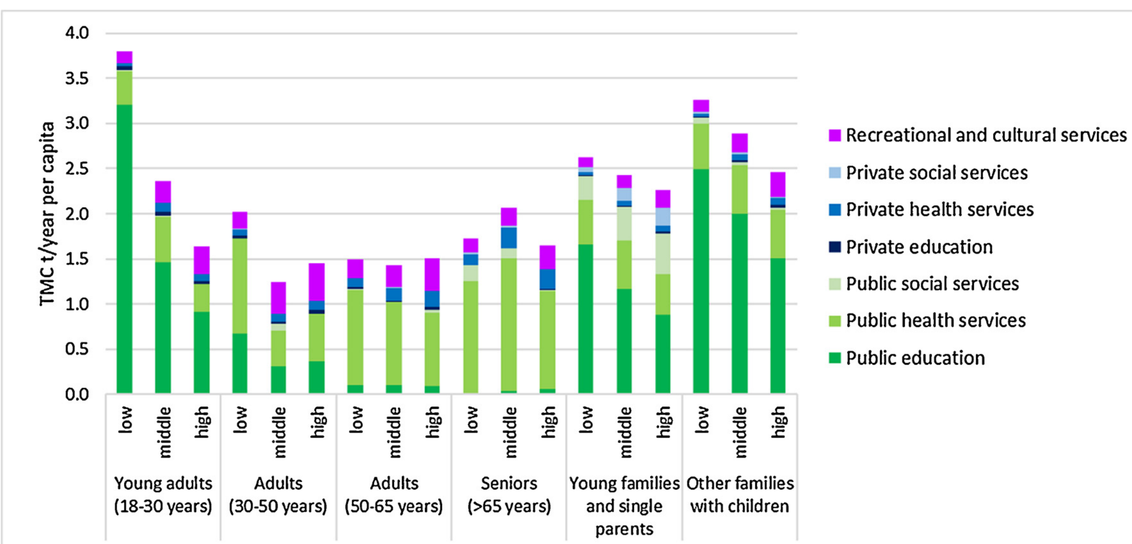

Fig. A2. The material footprint of public and private welfare services by household type and income group.

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