Unravelling the Greenhouse Gas Emissions of Household Consumption: A Decomposition Analysis of the Netherlands Between 2000-2019

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Master's thesis

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10th August 2022

Abstract

This study examined the relationship between climate change and household consumption in the Netherlands. During the period 2000-2019, the direct and indirect greenhouse gas emissions attributable to Dutch household expenditures were reduced from 151.7 to 127.1 $MtCO_2e$. The study aimed at understanding to what extent socioeconomic factors contributed to this reduction of emissions. Five driving factors were selected to be evaluated: population, household size, household demand, demand structure, and emission intensity. A combination of environmentally-extended input-output analysis and decomposition analysis was utilised to quantify each driver's impact on household GHG emissions. The results indicate that the estimated -24.6 Mt reduction of emissions was facilitated by three drivers and counterbalanced by two of them. Decreasing the emission intensity of consumption contributed -30.9 Mt, and lower household demand (after inflation) and a slight shift of consumption towards less emissive sectors added another -5.0 and -1.6 Mt each. In contrast, population growth and a decrease in household size were found to have raised household GHG emissions by 12.5 and 9.7 Mt, respectively. An amount of -9.3 Mt remained unexplained due to data inconsistencies. The findings underline the importance of decreasing emission intensities as mitigations realised this way have outpaced economic growth in the past two decades. At the same time, the results also highlight the powerful role of demographic trends prevailing in the Netherlands, which prospective climate policies are recommended to address to optimise GHG emission reductions.

Keywords: GHG emissions, household consumption, decomposition analysis, environmentally-extended input-output analysis, the Netherlands

Acknowledgements

This thesis work is the final step toward the completion of my master's education in Sustainable Development. It marks the end of two wonderful years I have spent at Utrecht University. My gratitude goes to my closest classmates and all teaching staff at the Copernicus Institute whose enthusiasm and creativity, for all pandemic restrictions, made this time unforgettable to me.

My supervisor Robert Harmsen deserves special thanks for that he has not only guided my way throughout this research project but also acted as a kind of a mentor during my entire master's studies. The sharp and sensible remarks that he gave me time after time greatly contributed to the final product and, I believe, ultimately made me a better sustainability professional.

Additionally, I would like to thank my second reader Wina Crijns-Graus for her observations in the early stages with which she positively influenced the direction of my work. My appreciation also goes to the staff members of Statistics Netherlands (CBS). Their diligent work laid the absolute foundations of my research.

And last but by no means least, I am endlessly grateful to my girlfriend, my family, and my friends. Their continuous support allowed me to pursue a complete university education in the Netherlands – at home, away from home.

Gergő Sütő

Utrecht, 10 August 2022

Contents

1 Introduction

1.1 Societal background

In recent years, several countries have set “climate targets” to guide the reduction of their greenhouse gas (GHG) emissions. While the sources of emissions are innumerable, the majority is likely to be driven by household consumption (estimated at 72% by Hertwich and Peters (2009) and 65% by Ivanova et al. (2016)). Reducing household consumption-driven GHG emissions requires the widespread adoption of sustainable consumption and production practices. Efforts have been undertaken to lower household consumption-driven GHG emissions (for the rest of the paper referred to as household GHG emissions). Concerned individuals contribute by adopting – depending on their capacity and willingness – more sustainable lifestyles (e.g. plant-based diets, commuting by public or non-motorised transport, recycling). Lifestyle changes have great potential for emission reduction if adopted by large parts of society but the complexity of influencing individual action has proved accomplishing radical changes difficult (Capstick et al., 2014; Grubb et al., 2020). Governments and the private sector have mostly addressed emission reduction via policies for efficiency improvements and the adoption of new technologies (Hickel & Kallis, 2020). While such emission saving measures are likely crucial for achieving climate targets, they risk being ultimately offset by increasing consumption levels, driven by factors such as (global) population growth or the absence of behavioural change (Rosa & Dietz, 2012). For this reason, it is important to address household consumption levels, what factors drive them and to understand how they contribute to a country’s GHG emissions.

1.2 Scientific background and knowledge gap

Research on establishing links between household consumption and environmental impacts started in the 1990s (Biesiot & Noorman, 1999; Lenzen, 1998), received considerable scientific attention in the 2000s (Hertwich, 2005; Kerkhof et al., 2009; Tukker & Jansen, 2006) and new studies are still been published (Clarke et al., 2017; Salo et al., 2021; Steen-Olsen et al., 2016). The use of environmentally extended input-output analysis (EEIO) for quantifying the link between consumption and emissions is virtually universal in all studies. Variations exist in how emissions intensities are estimated (Kok et al., 2006) and whether a model allows for multi-regional analysis (Steen-Olsen et al., 2016). Some studies went beyond linking emissions to household consumption and evaluated what factors drive consumption in the first place (Salo et al., 2021). Their findings prove useful not only for further research, i.e. highlighting which drivers are important to consider but also for formulating environmental policies.

A drawback of studies using EEIO analysis alone is that they analyse emissions in one or, occasionally, two years. They are not suitable for analysing changes over a period of time. For this reason, EEIO analysis has been combined with decomposition analysis (Cao et al., 2019; Das & Paul, 2014; Liu et al., 2010; Wang et al., 2015). Using this dual approach, typically called input-output decomposition (IOD) analysis, the development of emissions can be decomposed in terms of changes in the factors that drive them (Ang & Zhang, 2000). The set of drivers employed in studies depends on the research context and data availability, but always includes household expenditures and their emissions intensities. Studies using IOD for Northern/Western European countries are rare and often temporally and/or methodologically outdated; see De Haan (2001) for the Netherlands between 1987-1998, Yamakawa and Peters (2011) for Norway between 1990-2002, and Andreoni and Galmarini (2016) for several European and non-European countries before 2007. Schmidt et al. (2019) conducted a recent IOD study for Sweden, examining the GHG emissions of consumption over a twenty-year period between 1995-2014. This study, however, dealt with all kinds of consumption (e.g. by government) and thus was less focused on households.

1.3 Research objective and research questions

This study focused on the Netherlands, an affluent country of 17.7 million inhabitants located in Northwestern Europe. Climate mitigation in the Netherlands is guided on a national level since the ratification of the Dutch Climate Agreement (*Klimaatakkoord*) in 2019. This accord, accepted by both the government and private sector, requires the reduction of the country's GHG emissions by 49% until 2030 and 95% until 2050, compared to 1990 levels (Eerste Kamer der Staten-Generaal, 2019). While certainly ambitious, the targets set in the *Klimaatakkoord* cover only territorial (domestic) GHG emissions. The greenhouse gases emitted as a result of consumption in the Netherlands but taking place outside the Dutch borders are not subject to the same reductions. This limited scope allows for problem shifting by potentially outsourcing high emitting activities to other countries. To get a complete picture, this study addresses both domestic and extraterritorial emissions of Dutch household consumption. Evaluating the development of these emissions and its underlying drivers can benefit the design of prospective policies that support meeting the national targets while mitigating climate change globally. Accordingly, the study's *research objective* is to contribute to the policy understanding of recent trends in the relationship between consumption and climate change by assessing GHG emissions from Dutch household consumption in terms of their social, economic and environmental drivers. The study's policy relevance is increased by focusing on the evolution of household GHG emissions in the two decades prior to the *Klimaatakkoord* (i.e. 2000 to 2019), during which the policy attention to climate change vastly increased. Consequently, the research objective was translated into the following central research question:

(RQ) How are changes in Dutch household consumption-driven GHG emissions explained by changes in social, economic and environmental drivers during the period 2000-2019?

Finding the answer to the central research question was supported by a couple of sub-questions that delineated the work in smaller parts. First, quantifying consumption's climate impact required the determination of the emission intensities ($kgCO_2e/EUR$) for various household expenditure categories (e.g. per sector). Second, the time dynamics of drivers throughout the period of analysis needed observation to understand to what extent they could have contributed to the GHG emissions of households. Thus, the two sub-questions were formulated as follows:

(SQ1) What are the emission intensities of economic sectors producing for Dutch household consumption?

(SQ2) How did household GHG emissions and the selected social, economic and environmental drivers evolve in the period 2000-2019?

The central research question also necessitated the clarification of what social, economic and environmental drivers were going to be used in the analysis. Chapter 2 reviews the drivers used in prior studies and provides the final set of relevant drivers used in this research. The complete thesis is structured as follows. Chapter 2 provides the theoretical foundations of the research project which are connected in a conceptual framework. Chapter 3 translates this framework into research activities and explains how the findings answered the research questions. Chapter 4 presents the results of the research activities with a detailed description of the outcomes. The findings are then interpreted in Chapter 5 and three of the main limitations are discussed. Finally, Chapter 6 concludes the study's outcomes and considers their relevance for future climate policies.

2 Theory

This chapter presents the conceptual foundations of the proposed study. Subsection 2.1 introduces trend analysis, a first approach to the research problem, and discusses what its main benefits and limitations are for this study. Consequently, the application of decomposition analysis is put forward and argued to be the most suitable strategy to address the central research question. Once established, Subsection 2.2 describes the setup of the decomposition analysis, including what drivers were incorporated in the research. In Subsection 2.3, the components of the research setup are summarised in the study's conceptual framework, which then also gives directions for identifying the necessary research steps to be followed.

2.1 Research approach

One may attempt to analyse household GHG emissions by simply examining how they developed over time (i.e. between 2000 and 2019). Regardless of whether they increased, decreased or stagnated, the question may be what factors resulted in the observed trend. Did the number of consumers change? Did the number of households change? Did the amount of money they spent on products and services change? The evolution of these three variables, for example, could be plotted to give an idea of what socio-economic trends were observable in the Netherlands between 2000-2019. This simple trend analysis can indicate whether a certain socio-economic factor amplified or reduced household GHG emissions. What the trend analysis cannot answer, however, is how much of the changes in emissions are attributable to individual factors. A technique developed and used precisely for the above purpose is called decomposition analysis. Hoekstra and van den Bergh (2002) define decomposition analysis as a "comparative static analysis, which decomposes historical changes of an object/policy variable into determinant effects." In literature, Index Decomposition Analysis (IDA) and Structural Decomposition Analysis (SDA) are the two main decomposition techniques used. According to a literature review by Su and Ang (2012), IDA is mostly seen in studies that aim at understanding the drivers of energy use or emissions in a specific sector. SDA, on the other hand, is more applicable for researching the changes in emissions on an economy-wide level. Since household consumption spans the whole economy, this study used SDA as the guiding technique for the research at hand. The next subsection defines the fundamental elements of the decomposition analysis.

2.2 Setup of the decomposition analysis

The realisation of a successful SDA required attentive preparation of the analysis. This subsection presents the basic elements and techniques relevant to the decomposition study. First, the object variable of the study was defined as the amount of direct and indirect GHG emissions by Dutch household consumption and was denoted by the letter F. The decomposition problem then became the explanation of the change in emissions ΔF over the period 2000-2019:

$$\Delta F = F_{2019} - F_{2000} \tag{1}$$

2.2.1 Identification of drivers

The next step in setting up the decomposition analysis was the identification of relevant and accessible driving factors that may explain ΔF. The set of drivers is different in each study because the choice of one driver over another depends on the context and scope of the research, as well as the availability of reliable and relevant data sources. Accordingly, deriving the final set of drivers was an iterative process. What follows is a logical argumentation for a selection of drivers, as an outcome of drawing on prior studies and preliminary research on the available datasets. Table 1 presents an overview of five studies that also decomposed household GHG emissions. The table gives for each study the country of analysis, the driving factors used and, if applicable, the consumption domains by which consumption expenditures were grouped (see Section 2.4 for elaboration on consumption domains).

The reviewed studies differed in terms of their choice of a volume indicator. De Haan (2001) used economic activity (i.e. total demand), while others chose population, in which case economic activity became a structural indicator. Since the population of the Netherlands has not ceased growing, and its growth rate even accelerated to early 2000s levels before the COVID-19 pandemic, population was deemed a relevant factor and selected as the volume indicator of this study. To gain additional insight into demographic trends, household size (capita/household) was also included as the second driver. Household size has been indicated as an effective pre-

Table 1

Overview of similar IOD studies of consumption emissions

Study	Country	Drivers	Consumption domains
De Haan (2001)	Netherlands	Total demand, Demand structure, Production structure, Emission intensity	No grouping, 31 economic sectors
Schmidt et al. (2019)	Sweden	Population, Households, Consumption per capita, Product mix, Trade, Intermediate inputs, Emission intensity	Food, Shelter, Manufactured products, Mobility, Services, Construction & materials, and Other
Das and Paul (2014)	India	Population, GDP per capita, Demand structure, Energy intensity, Emission factor	Food, Clothing, Lifestyle effects, Education, Medical care, House building, Housing & lifestyle, Recreation, Transport
Wang et al. (2015)	China	Population, Urbanisation, Consumption level, Demand structure, Production structure, Emission intensity	No grouping, 22 economic sectors
Cao et al. (2019)	China	Population, Urbanisation level, Income level, Demand structure, Emissions intensity	Food, Clothing, Residence, Facilities, Transportation, Education, Health, Others

dictor of household emissions which tend to scale with the number of residents (Salo et al., 2021). Cao et al. (2019) and Wang et al. (2015) included an urbanisation effect (i.e. urban-rural population ratio). Cao et al. (2019) argued for its relevance in China as it had gone through intense urbanisation during their period of analysis. While urbanisation has also accelerated in the Netherlands (Statistics Netherlands, 2014), reliable consumption expenditure data could not be found separately for urban and rural households (see Section 3.1.4). Therefore, the study did not include an urbanisation effect. The available expenditure data allowed for the measurement of economic activity on a household level, i.e. total household expenditure divided by the number of households. This indicator, labelled 'household demand' in this study, corresponded to the spendings of the average Dutch household.

Household expenditures were accurately linked to GHG emissions with the use of two indicators: demand structure and emission intensity. The structure of demand measured the relative household expenditures (i.e. an increase/decrease of emissions due to relatively more/less spending on certain sectors). Coupling this information with the emission intensity of consumption in the same set of sectors allowed the estimation of GHG emissions. This concluded the final set of drivers, which were (1) population, (2) household size, (3) household demand, (4) demand structure and (5) emission intensity.

2.2.2 Decomposition identity

With regards to causality between drivers and GHG emissions, the following assumptions were made. Population, household demand, demand structure and emission intensity were proportional (+) to GHG emissions, i.e. increasing them would give rise to more emissions. Household size, on the other hand, was inversely proportional (–) to GHG emissions, i.e. an increasing number of residents per household leads to reduced emissions. Using the information discussed until now, the decomposition identity was established as:

$$F = \sum_i P \cdot \frac{1}{R} \cdot D \cdot S_i \cdot G_i = \sum_i P \cdot \frac{H}{P} \cdot \frac{T}{H} \cdot \frac{Y_i}{T} \cdot \frac{F_i}{Y_i} \tag{2}$$

In the decomposition identity, F represents GHG emissions from Dutch household consumption (kgCO_2e), P stands for population (capita), R represents the household size (i.e. the average number of residents per household, P/H, in capita/household), D is the total demand of the average household (T/H, in EUR/household), S_i represents the structure of demand, i.e. household expenditure on sector i (Y_i, in EUR) relative to total household expenditures (T, in EUR), and G_i is emission intensity of consumption from sector i (F_i/Xi in kgCO_2e/EUR).

The sectors categories which are indicated by the index i added an additional level to the decomposition analysis. They are identical to the industry classification in the Dutch National Accounts, which are in turn based on the European Union's NACE 2-digit standard. The complete list of sectors is given in Appendix A. Some scholars organised the household expenditures by domains or "commodity groups", such as food, transportation or housing. Table 1 gives the consumption domains used in some prior studies. The use of consumption domains may be useful because they can simplify the communication of results (see Section 2.4). For the sake of analysis, however, data was kept disaggregated to maximise the validity of the results.

2.2.3 Logarithmic Mean Divisia Index approach

In literature, several decomposition approaches exist to derive the contributions of driving factors to changes in the object variable (e.g. Laspeyres, Logarithmic Mean Divisia Index). The use of the Logarithmic Mean Divisia Index (LMDI) approach emerged in the late 1990s (Ang & Zhang, 2000) and has become the mainstream technique among SDA scholars due to its relatively simple methodology that nonetheless gives exact decomposition results (i.e. no residual terms produced). LMDI is also the approach used in more recent studies dealing with household GHG emissions (Cao et al., 2019; Das & Paul, 2014; Wang et al., 2015) and was therefore adopted in the research. The details of how LMDI was applied to this study are outlined in Section 3.2.

2.3 From production- to consumption-based emissions

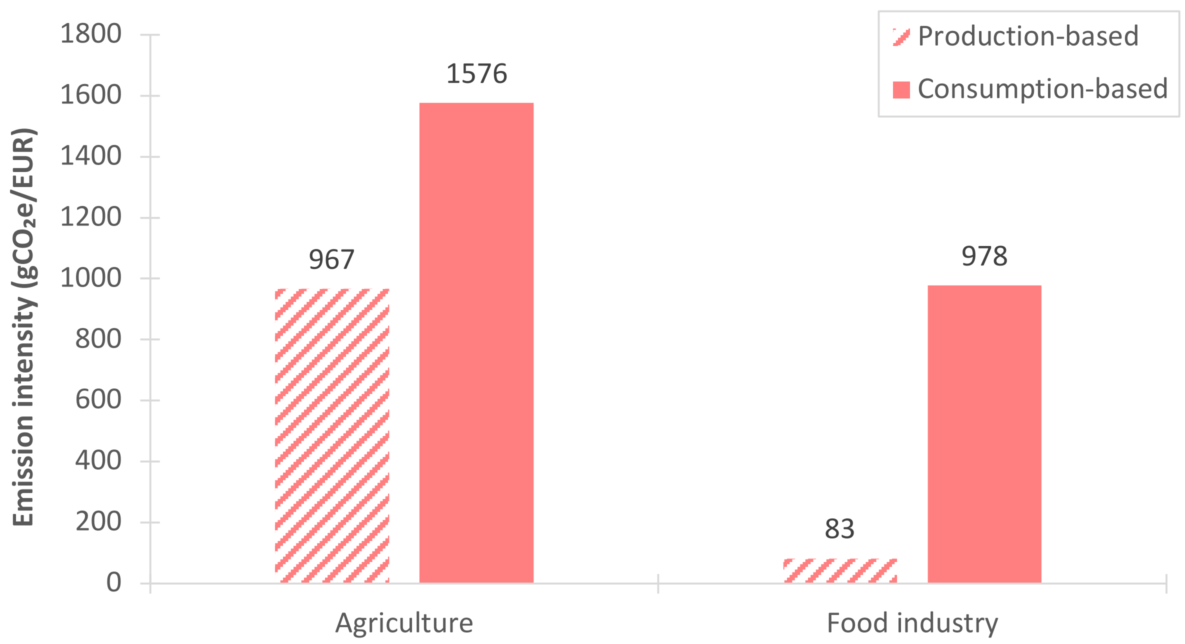
In many SDAs, the object variable is already quantified and available for analysis before the start of the research. This was not the case in this study because the GHG emissions associated with Dutch household expenditures are not reported in national statistics. To understand the difference between the reported emissions and household GHG emissions as defined in this paper, an important distinction has to be made between production- and consumption-based accounting. A sector's production-based emissions amount to the greenhouse gases directly emitted through their operations, such as running facilities, transporting products and personnel, etc. These are the emissions typically reported in statistics as they are relatively straightforward to measure. Production-based emissions are denoted by F_P in the remainder of this study.

For an economy-wide consumption study, such as this one, using the producer-perspective would mean that only direct emissions occurring in the sector which sells the final product to consumers are considered. This approach can result in misestimations, especially for sectors whose production is largely dependent on input from other, high-emission sectors. Consumption-based accounting gives a more complete picture as it also incorporates the emissions of production in sectors that are indirectly necessary to produce a final good or service: how much emissions occur in all sectors so that sector X can produce a unit of output?

Figure 1 illustrates the difference between production- and consumption-based accounting by displaying the GHG intensities of agriculture and the food industry in 2019. From a production perspective, the food industry's GHG intensity (83 gCO_2e/EUR) is more than a mag-

Figure 1

Production- and consumption-based emission intensities of agriculture and the food industry, 2019 (own estimations)



nitude less than that of agriculture (967 gCO_2e/EUR). This representation, however, hides the fact that the food industry's output originates to a large extent in agricultural produce (which in turn depends on other sectors for machinery, fertilisers etc.). Accounting for such inter-sectoral interactions gives a different picture as the two sectors' consumption-based GHG intensities grow much closer to each other (1576 and 978 gCO_2e/EUR for agriculture and the food industry, respectively). Using consumption-based emissions and emission intensities is therefore crucial when analysing (household) consumption emissions.

The standard approach for deriving consumption-based emissions and emission intensities is by using Environmentally-Extended Input-Output (EEIO) analysis. The backbones of this technique are the so-called input-output tables which record, among other information, the monetary transactions between and within sectors as well as between sectors and households. Applying the Leontief method to input-output tables, one can derive how much of a unit of production in one sector is attributable to production in all sectors (Leontief, 1986):

$$L = (I - A)^{-1} \tag{3}$$

where L is the $N \times N$ Leontief inverse matrix, I is the $N \times N$ identity matrix, A is the $N \times N$ normalised matrix of intermediate consumption, and N is the number of sectors. The Leontief inverse matrix then enables the redistribution of sectoral GHG emissions from a consumption perspective:

$$F_C = G_P \cdot L \cdot Y \tag{4}$$

where F_C are the consumption-based GHG emissions of Dutch household consumption, including both direct and indirect emissions. G_P is the $1 \times N$ vector of production-based emission intensities of Dutch economic sectors (i.e. a sector's production-based emissions divided by its output). Note that, consequently, the emission intensities of Dutch sectors were assumed for the production of goods and services taking place abroad (see further in Section 5.2.1. Finally, Y is the $N \times 1$ vector of final household consumption expenditures, including imported goods and services. The variable F_C, referred to as *household GHG emissions* in the rest of the paper was the object/policy variable of this study.

2.4 Consumption domains

A country's economy can be divided into several dozens of sectors. Performing the decomposition analysis at the highest possible resolution is important to gain maximum insight. Interpreting the emission reductions of more than 70 sectors, however, can prove inconvenient for a reader. To help this issue, some studies introduced the grouping of sectors by the consumption purposes they fulfil. These categories are often called commodity groups or, more broadly, consumption domains. Table 1 showed earlier the consumption domains applied, if any, in the studies reviewed earlier. Possibly the most comprehensive and intuitive categorisation was put forward in a study by the Institute for Global Environmental Strategies et al. (2019). Their 6-group scheme was adopted in this thesis with slight changes. The six consumption domains were then defined as follows:

1. Nutrition: sectors primarily supplying foodstuff, beverages and tobacco and relevant services, e.g. agriculture, food industry, restaurants and cafés [1];

2. Housing: sectors related to the provision of accommodation and utilities, e.g. construction, maintenance, renting, energy and water supply;

3. Mobility: sectors related to personal transportation for commuting, leisure or other purposes, e.g. land-, water-, and air travel, car and other transport equipment [2];

4. Consumer goods: sectors supplying goods and materials not covered under other domains, e.g. clothing, electrical appliances, and daily consumer items [3];

5. Leisure: sectors related to leisure activities performed outside of the home, e.g. culture, sports, entertainment, and hotel services;

6. Services: sectors related to personal services, e.g. healthcare, telecommunications, insurance.

[1] Direct emissions of cooking at home are counted under housing

[2] Business trips are incorporated in the respective domain of the goods or services supplied

[3] Energy used by appliances are counted under housing

The complete list of sectors assigned to consumption domains can be found in Appendix B. Note that the analysis was still carried out at the sector level and the aggregation to consumption domains was only applied when presenting the result.

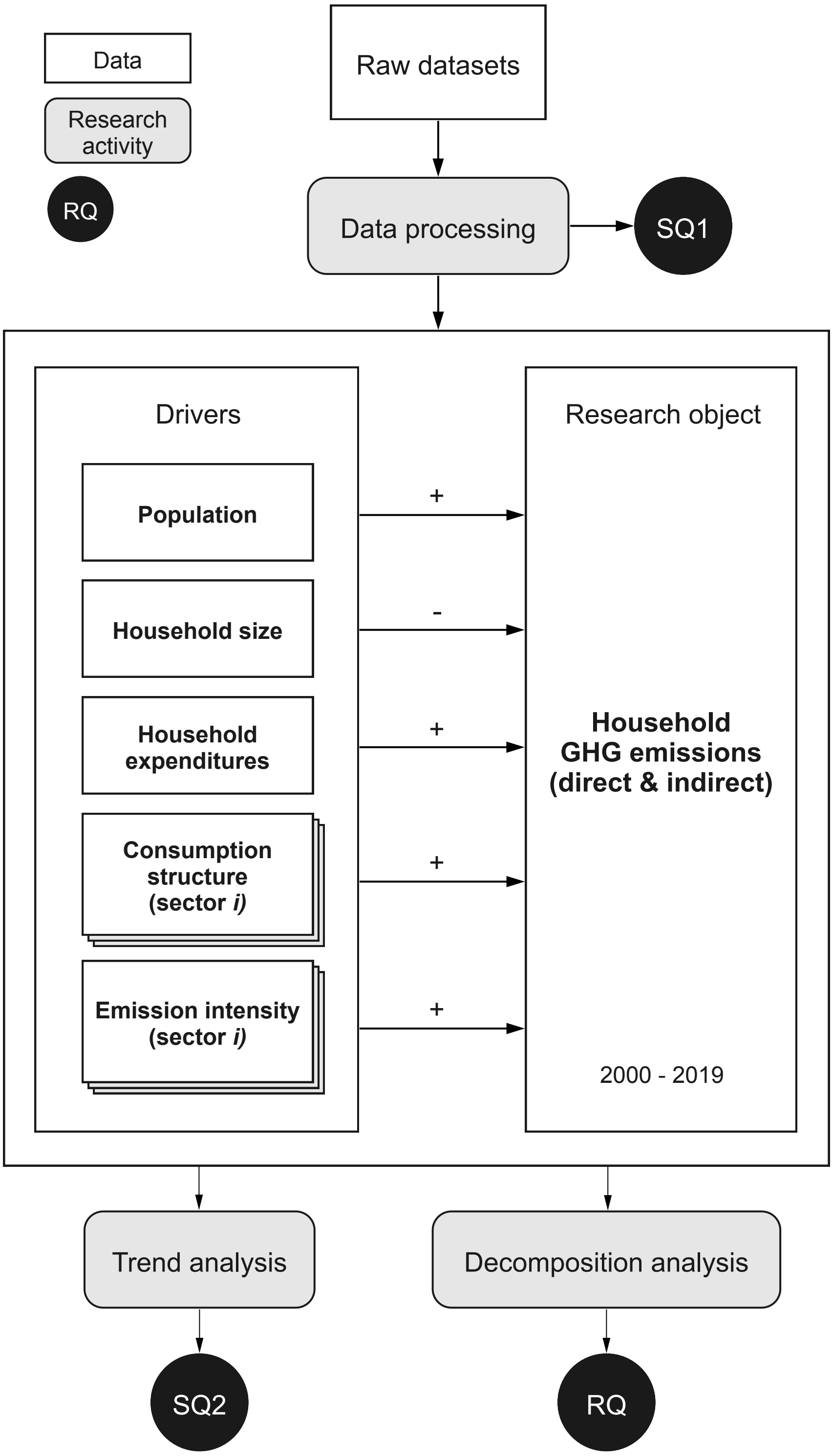
2.5 Research steps and conceptual framework

Based on the contents of this chapter so far, the main concepts and techniques of the study are organised into a conceptual framework, shown in Figure 2. The white squared boxes represent the research object (household GHG emissions) and the five selected drivers. The grey rounded boxes constitute the three general research activities (data preparation, trend analysis and structural decomposition analysis). The relations between the research object and the five drivers are represented by arrows and a (+) or (–) sign for the proportionality or inverse proportionality of the relation, respectively. Finally, the dark circles show which (sub-)research question was answered upon the completion of an activity.

Data preparation was required to structure the raw data sources in a way that was suitable for application in the trend and decomposition analyses. An important part of data preparation was the derivation of each sector's emission intensity, which concluded the first sub-question (SQ1). Second, the evolution of the five driving factors, as well as household GHG emissions from 2000 to 2019, were visualised and examined qualitatively. This trend analysis provided useful information for the decomposition analysis (i.e., in what direction drivers influenced emissions) and answered the second sub-question (SQ2). Lastly, using all information derived in the first two steps, the decomposition analysis was carried out. Completion of this step yielded an estimation of how much of the changes in Dutch household emissions between 2000-2019 are attributable to changes in the five driving factors, which was the answer to the central research question (RQ). Next, Chapter 3 describes the specific research steps for the three general activities.

Figure 2

Conceptual model



3 Methods

The research setup outlined in the previous chapter is delineated into specific research steps in this chapter. Section 3.1 presents the trend analysis and how the data sources were dealt with in the construction of each indicator. Section 3.2 describes precise the decomposition process that was followed in the study.

3.1 Data preparation and trend analysis

As a preliminary step to decomposition analysis, the developments of household GHG emissions and driving factors were examined. This trend analysis called for the structuring of data into the six variables as shown in the conceptual framework. How these variables were measured, what data sources were available and how they were processed, are described in the rest of this subsection.

3.1.1 Household GHG emissions

Consumption-based household GHG emissions F_C, the study's object variable, was derived by combining monetary information from input-output tables, production-based emissions of economic sectors F_P, and import-inclusive household consumption expenditures Y. Their mathematical relation to household GHG emissions F_C are specified in Equations 3-4. The methods connected to I/O tables and F_P are outlined below, while household consumption expenditures Y are detailed in Section 3.1.4.

The input-output tables are annually published as part of the Dutch National Accounts. After consultation with Statistics Netherlands *(CBS)*, the most recent versions were obtained from two sets, one for the years 2000-2015 (Statistics Netherlands, n.d.) and another for 2015-2020 (Statistics Netherlands, 2021d). All tables were corrected for inflation by adjusting their values to 2015 euros, using the World Bank's GDP deflator dataset for the Netherlands (World Bank, 2022).

The input-output tables came in two sets due to an update of methodology in 2018 (Statistics Netherlands, 2018). For the year 2015, tables with both the 'new' and 'old' methodologies were available. The new methodology brought about two major changes that were relevant for this study. First, the number of sectors increased from 76 to 81 as some sectors were disaggregated into sub-sectors (e.g. "Arts, culture and gambling" were separated into three); see Appendix A for the complete sets of sectors. While this discontinuity caused some inconvenience for the decomposition analysis, the input-output tables were not adjusted in this regard because restructuring them was well beyond the scope of this study (if possible at all due to a lack of data).

The other issue was found in how economic activities were estimated, apparent from comparing the 'old' and 'new' 2015 tables. For example, the sum of total sector outputs in the more recent table (€1.34 trillion) is higher than the earlier estimation (€1.28 trillion) by 4.7%. Since this statistical increase in economic activity would result in lower emission intensities and thus an artificial drop in GHG emissions, it was decided that sector output values had to be adjusted. Effectively, this meant that total sector outputs in the 'new' 2015 table were scaled such that their sum equalled that of the 'old' 2015 table (i.e. multiplying them by $\sim$0.9554). This scaling factor was then applied the same way to the 2016-2019 tables for consistency reasons. For the consequences of pre- and post-2015 input-output table differences and their adjustments, see the discussion in Section 5.2.3.

Production-based emissions F_P, the precursor of household GHG emissions F_C as seen in Equation 4, were obtained from the dataset "Emissions to air by Dutch economy" (Statistics Netherlands, 2021a). This source gave the production-based emissions of 53 economic activities. To make them mathematically compatible with I/O tables, the 53 emission values were mapped to economic sectors (76/81 for tables with old/new methodology) and split in proportion to their final outputs. Since the classification of the 53 economic activities mostly followed the NACE 2-digit standard and thus roughly coincided with the economic sectors in I/O tables, the mapping procedure was fairly straightforward. For example, the emission category "Agriculture, forestry and fisheries" could easily be divided into the three economic sectors "Agriculture", "Forestry", and "Fisheries". Most categories were similarly split, while others could be matched one-on-one to a sector. The only two emission categories that required specific processing were "Transport by private households" and "Other private household activities" as they are not economic sectors on their own. Emissions from "Transport by private households" were divided and added to the three sectors Land-, Water-, and Air transport, proportionally to each sector's final output to households. As for the category "Other private household activities", it could not be determined which sectors it linked to and therefore was simply split among all sectors (again proportionally to each sector's final household demand). See Appendix C for the precise mapping of emission categories to economic sectors.

Finally, combining the above information using Equations 3-4 gave the GHG emissions of Dutch household consumption. Note that the resulting estimates integrated emissions occurring both inside and outside the Netherlands because household expenditures Y included both domestically produced as well as imported goods and services. Consequently, this approach also meant that the emission intensities of Dutch economic sectors were assumed for production taking place abroad (see discussion in Section 5.2.1).

3.1.2 Population

As for drivers, the first one to be examined was population P. This basic demographic information was measured in capita and incorporated population change from both natural change and migration. Statistics Netherlands provided population statistics for the period 2000-2019 with capita accuracy (Statistics Netherlands, 2021c). This data required no additional processing.

3.1.3 Household size

In this study, the driver household size R was measured as the ratio of the population P by the total number of households H in the Netherlands. The latter information was available annually in national statistics (Statistics Netherlands, 2021b). This dataset did not need additional processing and was applied directly to calculate the average household size.

3.1.4 Household demand

The driver household demand D was more complicated to deal with. In this study, the definition of household expenditure was not purely theoretical but was impacted by data availability. The most comprehensive and reliable measurement of Dutch household expenditures was found in the dataset "Consumption by type of goods and services" (Statistics Netherlands, 2022a). This source gave the expenditures made by Dutch households on distinctive consumption categories; see Table 2 for the 32 expenditure categories. The added value of this dataset is that it incorporates expenditures on imported goods and services on a disaggregate level, as opposed to input-output tables which only specify direct household imports in terms of goods and services (i.e. two aggregate categories). Consequently, household demand D (EUR_{2015}/household) was measured as the ratio of the total amount of expenditures by Dutch households T and the number of households H.

Table 2

Household expenditure categories (Statistics Netherlands, 2022a)

Code	Description	Code	Description
C1	Potatoes, fruit and vegetables	C17	Motor fuels
C2	Meat and meat products	C18	Personal care products
C3	Fish	C19	Other goods
C4	Dairy, eggs, oils and fats	C20	Actual rent
C5	Bread products, pastry & cakes	C21	Imputed rental value own dwelling
C6	Groceries	C22	Services related to house & garden
C7	Non-alcoholic beverages	C23	Food and beverage service
C8	Alcoholic beverages	C24	Accommodation
C9	Tobacco	C25	Recreational services
C10	Clothing and textiles	C26	Cultural services
C11	Shoes and leather goods	C27	Transport services
C12	Furnishings & home decoration	C28	Communication services
C13	Electrical equipment	C29	Medical services
C14	Transport equipment	C30	Welfare services
C15	Other durable goods	C31	Financial and business services
C16	Energy and water	C32	Other services

3.1.5 Demand structure

Besides the total expenditures of households, it matters what households spend their money on, as the consumption of certain commodities is associated with higher emissions than others. In the current study, the consumption pattern of households was reflected in the driver demand structure S_i (EUR/EUR). It was measured as the household expenditure Y_i on sector i relative to the total expenditures of Dutch households T. Since the number of expenditure categories in import-inclusive expenditure statistics (32) and the number of economic sectors in I/O tables (76 for 2000-2015, 81 for 2015-2019) were different, they required some level of processing for the EEIO and decomposition analyses to be mathematically compatible. Input-output tables are far too complex to shrink, thus the expenditure data were expanded by mapping the 32 expenditure categories to the 76/81 sectors of input-output tables. In fact, the two datasets are both parts of the Dutch National Accounts and the first is supposedly derived from the second, however, the mapping methodology could not be uncovered from the documentation. Consequently, an alternative mapping was created, which followed a similar structure as the disaggregation of reported emissions to sectors seen earlier. Appendix D gives the detailed keys as to how the mapping was carried out.

3.1.6 Emission intensity

The fifth and last indicator of this study was the emission intensity of economic sectors. Note that this indicator represents the consumption-based emission intensity of sectors, as opposed to the production-based counterpart introduced in Equation 4. To mark this difference, it is denoted as G_C but is referred to as emission intensity for simplicity. Emission intensity G_C can be derived by adapting Equation 4 to yield just emission intensity (instead of emissions):

$$G_C = G_P \cdot L. \tag{5}$$

This calculation was carried out using the input-output tables and production-based emissions as described in Section 3.1.1. This step yielded the consumption-based emission intensity of each sector in each year and marked the end of data preparation.

3.2 Decomposition analysis

Once household GHG emissions and driving factors were quantified, the decomposition analysis began. This section describes the decomposition process that was followed. According to the SDA technique and the setup of this study, the change of GHG emissions F_C between the base year (0) and target year (T) could be decomposed in:

$$\begin{aligned}\Delta F_C = \Delta F_{C,T} - \Delta F_{C,0} = \sum_i P_T \cdot R_T \cdot D_T \cdot S_{T,i} \cdot G_{C,T,i} \\ - \sum_i P_0 \cdot R_0 \cdot D_0 \cdot S_{0,i} \cdot G_{C,0,i}\end{aligned} \tag{6}$$

As mentioned in Section 2.2.3, the decomposition was carried out with the LMDI method. Using LMDI, the change in GHG emissions could be decomposed into 5 effects:

$$\Delta F_C = \Delta F_C^P + \Delta F_C^R + \Delta F_C^D + \Delta F_C^S + \Delta F_C^G \tag{7}$$

where the contributions of the drivers to GHG emissions were represented by the population, household size, household expenditure, demand structure and emission intensity effects:

$$\text{Volume effect: } \Delta F_C^P = L(F_{C,0}, F_{C,T}) \cdot \ln \frac{P_T}{P_0}, \tag{8}$$

$$\text{Structure effect 1: } \Delta F_C^R = L(F_{C,0}, F_{C,T}) \cdot \ln \frac{R_0}{R_T}, \tag{9}$$

$$\text{Structure effect 2: } \Delta F_C^D = L(F_{C,0}, F_{C,T}) \cdot \ln \frac{D_T}{D_0}, \tag{10}$$

$$\text{Structure effect 3: } \Delta F_C^S = \sum_{i=1}^{N} L(F_{C,0,i}, F_{C,T,i}) \cdot \ln \frac{S_{T,i}}{S_{0,i}}, \tag{11}$$

$$\text{Emission intensity effect: } \Delta F_C^G = \sum_{i=1}^{N} L(F_{C,0}, F_{C,T}) \cdot \ln \frac{G_{C,T,i}}{G_{C,0,i}}, \tag{12}$$

and the logarithmic mean of two numbers $L(a,b)$ is defined as:

$$L(a,b) = \frac{b-a}{\ln \frac{b}{a}} \tag{13}$$

The base year 0 and the target year T, for the overall analysis, were the years 2000 and 2019, respectively. The length of this period was relatively long and performing the decomposition between only the base and target years would hide trends that occurred throughout the nearly two decades. The resolution of decomposition was increased to improve the accuracy of the results. Since all datasets were available on at least a yearly basis, the decomposition was carried out for each year and the annual effects were summed up. The extended equations for the five effects are as follows:

$$\Delta F_C^P = \sum_{t=2000}^{T-1} L(F_{C,t}, F_{C,t+1}) \cdot \ln \frac{P_{t+1}}{P_t} \tag{14}$$

$$\Delta F_C^R = \sum_{t=2000}^{T-1} L(F_{C,t}, F_{C,t+1}) \cdot \ln \frac{R_t}{R_{t+1}} \tag{15}$$

$$\Delta F_C^D = \sum_{t=2000}^{T-1} L(F_{C,t}, F_{C,t+1}) \cdot \ln \frac{D_{t+1}}{D_t} \tag{16}$$

$$\Delta F_C^S = \sum_{t=2000}^{T-1} \sum_{i=1}^{N} L(F_{C,t}, F_{C,t+1}) \cdot \ln \frac{S_{t+1,i}}{S_{t,i}} \tag{17}$$

$$\Delta F_C^G = \sum_{t=2000}^{T-1} \sum_{i=1}^{N} L(F_{C,t}, F_{C,t+1}) \cdot \ln \frac{G_{C,t+1,i}}{G_{C,t,i}} \tag{18}$$

Performing decomposition on an annual basis did not only improve the results but also enabled the analysis of intermediate effects, such as the influence of the 2008 financial crisis. The realisation of the decomposition analysis provided the answer to the central research question and, by doing so, concluded the research activities.

4 Results

This chapter presents the outcomes of the research activities. Section 4.1 begins with observing the development of household GHG emissions as well as the selected socio-economic drivers between 2000 and 2019. Results are primarily given only for the base and target years of the study, with higher resolution added wherever the underlying trends showed non-linearity. Section 4.2 then gives the results of the decomposition analysis in terms of 1) socio-economic drivers, 2) years, and 3) sectors.

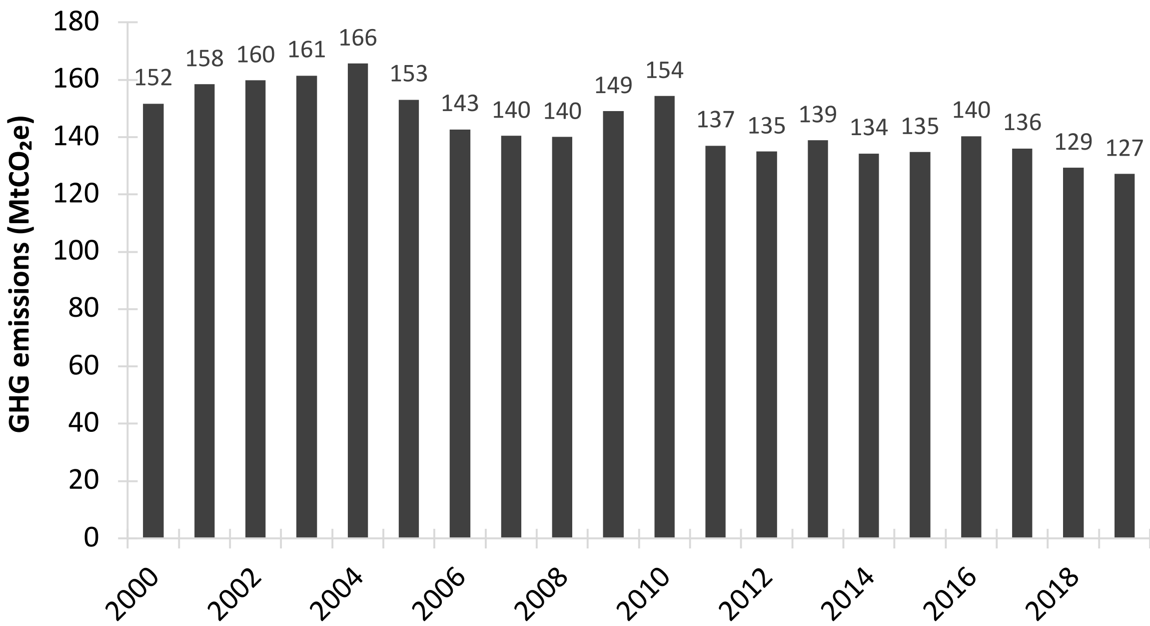
4.1 Trend analysis

4.1.1 Household GHG emissions trends

As a starting point for the analysis, we first look at the emission estimates of the EEIO model constructed for this study. Figure 3 shows the estimates for each year between 2000 and 2019. Household GHG emissions amounted to 152 $MtCO_2e$ in 2000 and were reduced to 127 Mt (-16%) in 2019. This last year was also their lowest level during the period, while the highest was reached in 2004 with 166 Mt. Generally speaking, emissions were gradually decreasing

Figure 3

Consumption-based GHG emissions of Dutch household consumption

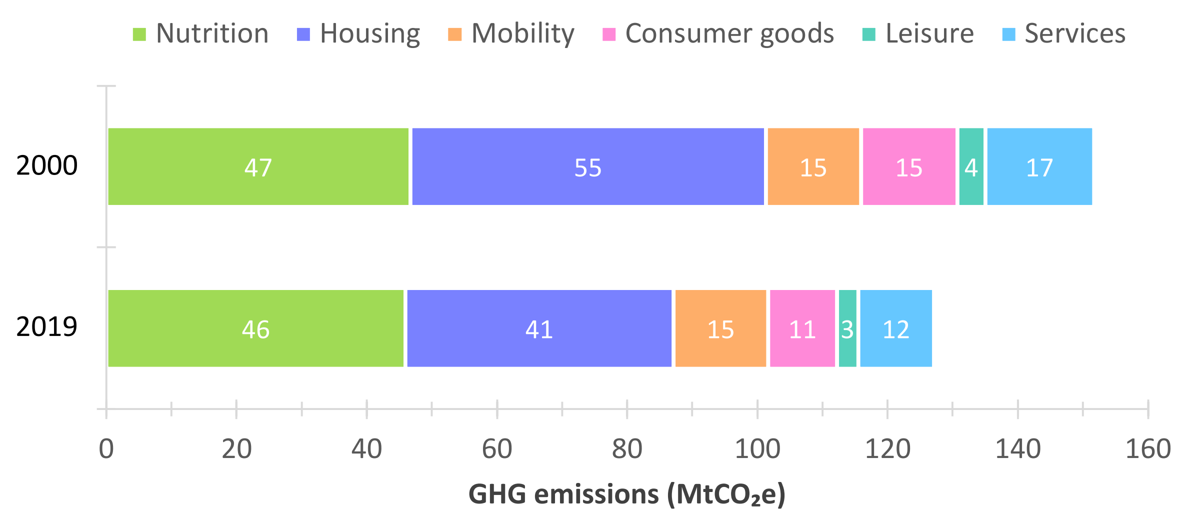


from 2004 onwards with two notable setbacks around 2009-2010 and 2016. Comparable trends are observed in economy-wide GHG emission estimates by the World Resources Institute (2022) as well as a 2016 study by Statistics Netherlands (2016).

Household GHG emissions were broken down into consumption domains. Figure 4 displays the 2000 and 2019 emissions in terms of consumption in six domains (what exactly constitutes the domains is detailed in Appendix B). In both base and target years, most GHG emissions were associated with nutrition and housing-related expenses. While emissions from nutrition remained rather constant (46-47 $MtCO_2e$), housing decreased substantially from 55 to 41 Mt. This was mainly achieved by the decarbonisation of the energy supply to households as the consumption-based emissions of ‘energy companies’ decreased from 31.0 to 22.4 Mt. Emissions from services (e.g. healthcare, governmental, and financial services) were also significantly reduced from 17 to 12 Mt (-29%). Expenses on mobility and consumer goods were both estimated at 15 Mt in 2000. While emissions of consumer goods have been reduced to 11 Mt in 2019, those associated with mobility stagnated around 15 Mt throughout the period. The least emissions were attributed to leisure activities (3-4 Mt), constituting 2-3% of all household GHG emissions.

Figure 4

Dutch household GHG emissions by consumption domains, 2000 and 2019



4.1.2 Population trends

The population of the Netherlands showed a moderate but steady increase in the first two decades of the 21st century. As shown in Table 3, the number of inhabitants grew from 15,863,950 in 2000 to 17,282,163 in 2019, expanding by 1,418,213 (9.73%). Figure 5 shows the growth rate in terms of natural change and migration. In the early 2000s, annual population growth was relatively high (0.78% in 2000 and 0.74% in 2001) and natural change and migration contributed almost equally in these years. Slowing natural increase and net emigration brought population growth to 0.15% in 2006, its lowest point during the period of analysis. The significance of natural change steadily declined through the years from 0.42% in 2000 to 0.10% in 2019 (and further to 0.00% in 2020 due to the COVID-19 pandemic). Simultaneously, migration varied in numbers but recently showed an increasing trend from contributing 0.08% in 2012 to 0.63% in 2019 to population growth. The resulting 0.73% population increase in 2019 can be considered relatively high when compared to other European countries, e.g. Belgium 0.58%, Denmark 0.29%, Germany 0.18% (Eurostat, 2021). Due to the COVID-19 pandemic, the trends have discontinued, and both natural growth and immigration stalled. It is yet unclear what demographic trends will be observed in the Netherlands in post-pandemic years, but the growth of population between 2000 and 2019 was certainly instrumental in raising household GHG emissions.

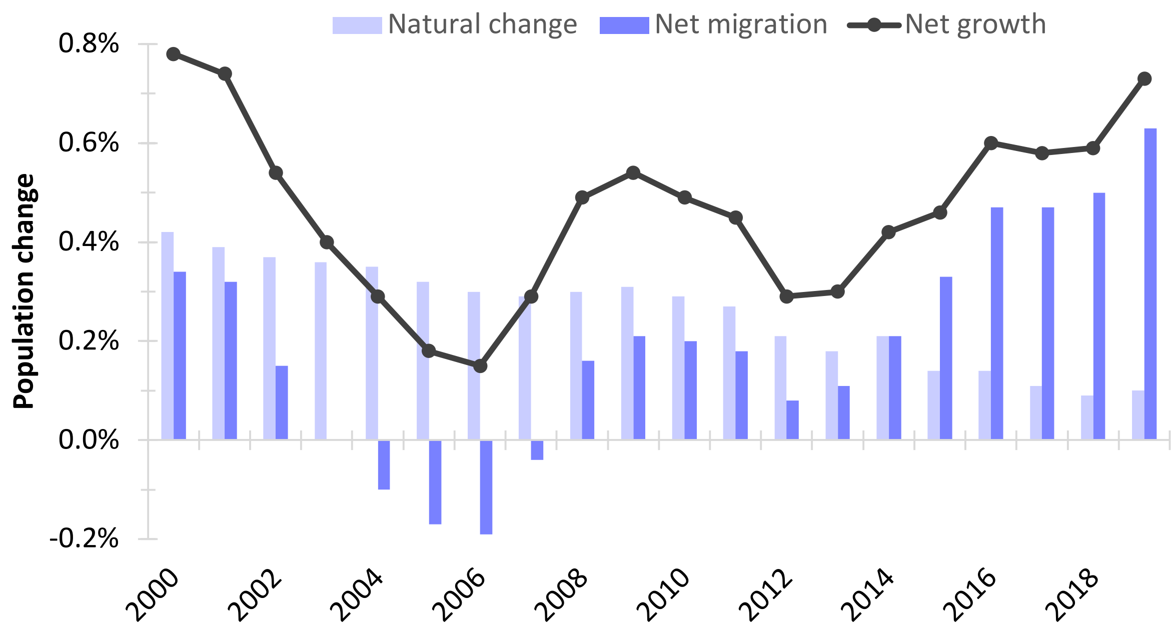
Table 3

Population of the Netherlands 2000-2019 (Statistics Netherlands, 2021c)

Year	Population	Change
2000	15,863,950	
2005	16,305,526	2.78%
2010	16,574,989	1.65%
2015	16,900,726	1.97%
2019	17,282,163	2.26%

Figure 5

Population growth in the Netherlands 2000-2019 (Statistics Netherlands, 2021c)



4.1.3 Household size trends

In 2019, the population of the Netherlands accommodated in 7.92 million households. This figure is up from 6.80 million in 2000, corresponding to an increase of about 59 thousand or 0.81% of new households annually. Table 4 shows the development of household size for every five years between 2000 and 2019. The average household size showed a slightly decreasing trend from 2.33 in 2000 to 2.18 in 2019. Worldwide this makes the Netherlands one of the few

Table 4

Average household size and its change over the prior five years in the Netherlands, 2000-2019

Year	Avg. household size	Change
2000	2.33	
2005	2.30	-1.31%
2010	2.24	-2.41%
2015	2.20	-1.75%
2019	2.18	-1.28%

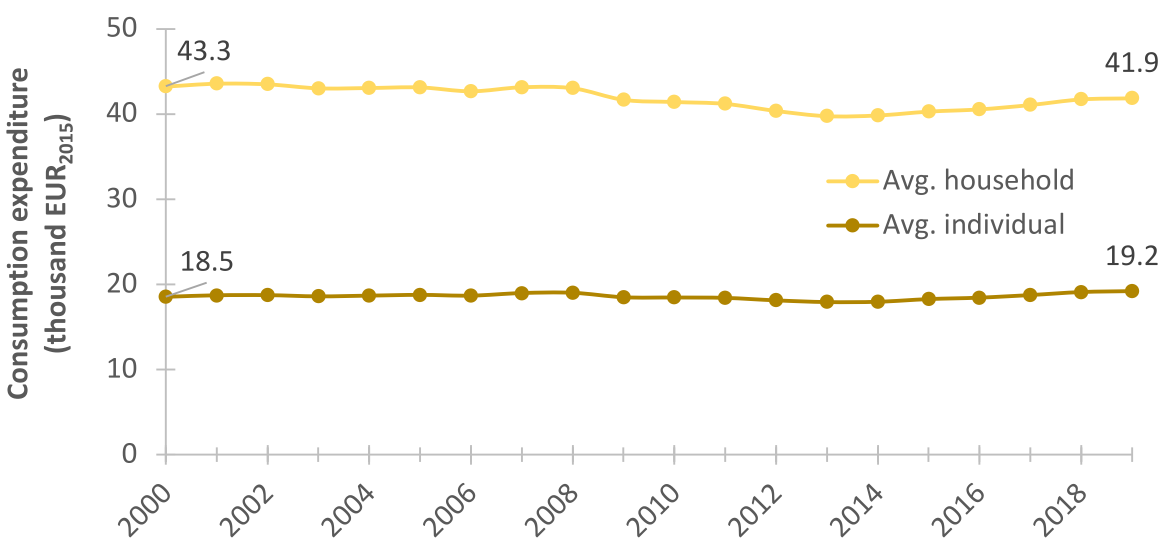
countries with an average household size below 2.25 (United Nations, 2019). Consequently, the decreasing tendency of household size promoted the increase of household GHG emissions.

4.1.4 Household demand trends

In terms of household demand D, some moderate trends can be observed. In 2000, the average Dutch household spent €43,300 (in 2015 euros) which amount decreased to €41,900 in 2019 (see Figure 6). This decline, while genuine, is tricky to interpret as a household's expenditures are inherently tied to its number of inhabitants, which also decreased as seen in Section 4.1.3. Average household expenditures decreased by -3.2% while household size by -6.4%, suggesting that the per capita expenditures actually increased. Figure 6 also plots the average individual consumption expenditures (T/P) and shows that they indeed increased by 3.8%, from €18,500 to €19,200. Note that the trends were not exactly linear as the 2008-09 financial crisis hampered expenditures between 2008-2013, mostly evident in household expenditures which fell by -7.6%. Conclusively, the slight overall reduction of household expenditures D between 2000 and 2019 contributed to a reduction of household GHG emissions F_C.

Figure 6

Average household and individual expenditures, 2000-2019

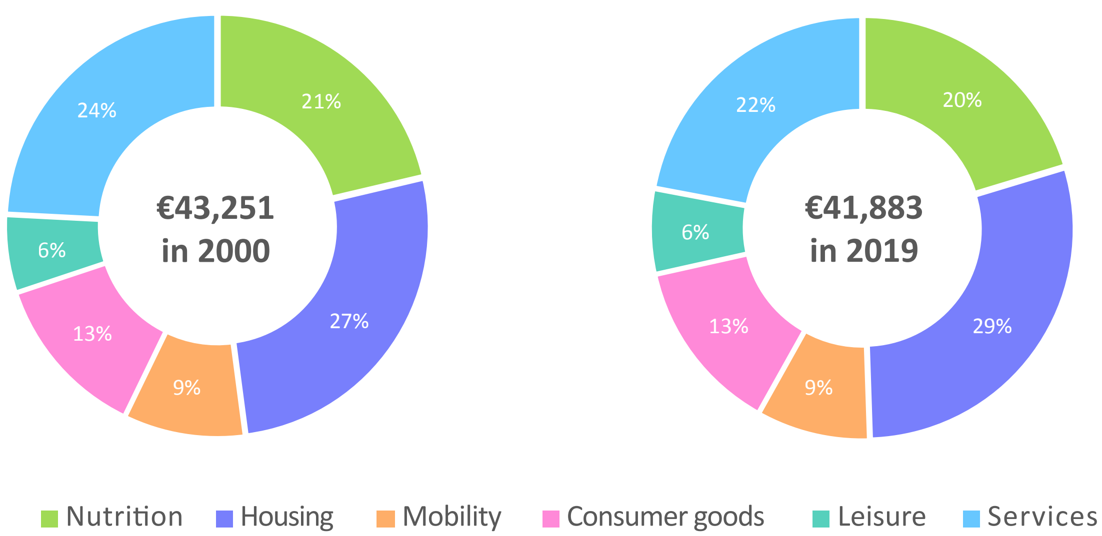


4.1.5 Demand structure trends

The relative spendings, represented by the indicator demand structure S, showed only moderate changes between 2000 and 2019. Figure 7 shows household expenditures in base and target years, broken down by six consumption domains. While the average household's overall expenditure decreased from €43,251 to €41,883, the shares of expenditures stayed rather constant. The largest shares of expenses went to housing (27-29%), services (22-24%) and nutrition (20-21%). The proportion of housing-related expenditures increased by 2 percentage points, mostly driven by rising rental and dwelling prices, while services and nutrition received 2 and 1 percentage point less, respectively. The relative spendings on consumer goods (13%), mobility (9%) and leisure activities (6%) did not change substantially. Overall, it was difficult to determine whether the changes in demand structure increased or decreased household GHG emissions and therefore this trend analysis was deemed inconclusive. In any case, the impact of demand structure on emissions is likely to have been minor.

Figure 7

Spendings of the average Dutch household in 2000 and 2019

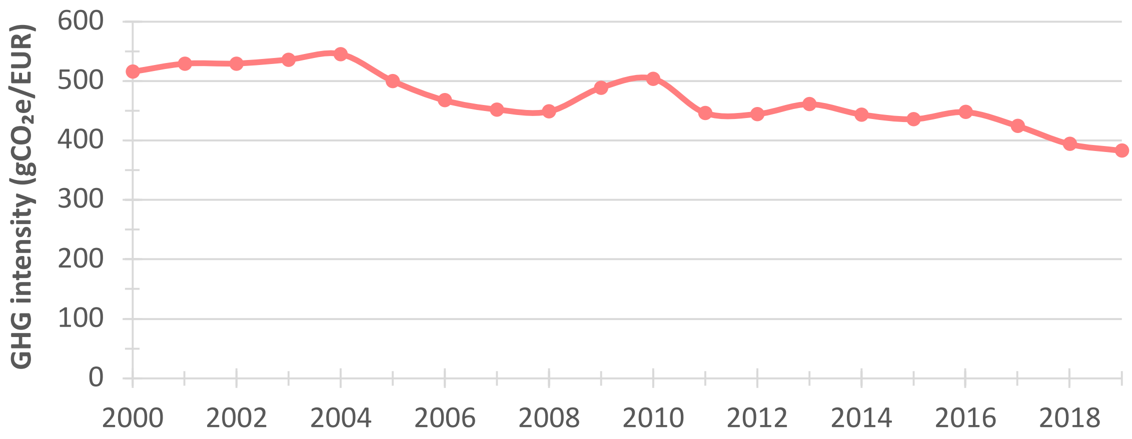


4.1.6 Emission intensity trends

The emission intensity of consumption also experienced a gradual reduction between 2000 and 2019. One euro of consumption required 0.516 kgCO_2e of emissions in 2000, which figure was reduced to 0.383 kg in 2019. Emission intensity's trendline is comparable to that of emissions seen in Section 4.1.1, with intermediate peaks in 2004, 2010 and 2016 and reaching its lowest level in 2019. This observation suggests that emission intensities were important determinants in the reduction of household GHG emissions between 2000 and 2019.

Figure 8

Emission intensity of Dutch household consumption, 2000-2019



4.1.7 Synthesis

The outcomes of the trend analysis of the five indicators are recapped in this brief synthesis. Table 5 summarises the findings by indicating in which direction the indicators influenced household GHG emissions. It is clear that the overall reduction of -24.6 MtCO_2e was achieved by a combination of factors. The trend analysis showed that population growth and a shift towards smaller households contributed to an increase of emissions, while lesser household spendings and lower emission intensities of goods and services helped mitigate them. The influence of changes in demand structure could not be clearly determined, though its effect is likely to be small. How much of the reduction was exactly attributable to the various indicators is described in the following section on decomposition analysis.

Table 5

Overview of driver trends and the direction of their impact on household GHG emissions

	Change 2000-2019	Impact on household GHG emissions (F_C)
Population (P)	8.9%	(+) Increase
Household size (R)	-6.5%	(+) Increase
Household demand (D)	-3.2%	(–) Decrease
Demand structure (S)	N/A	(±) Inconclusive
Emission intensity (G_C)	-25.7%	(–) Decrease

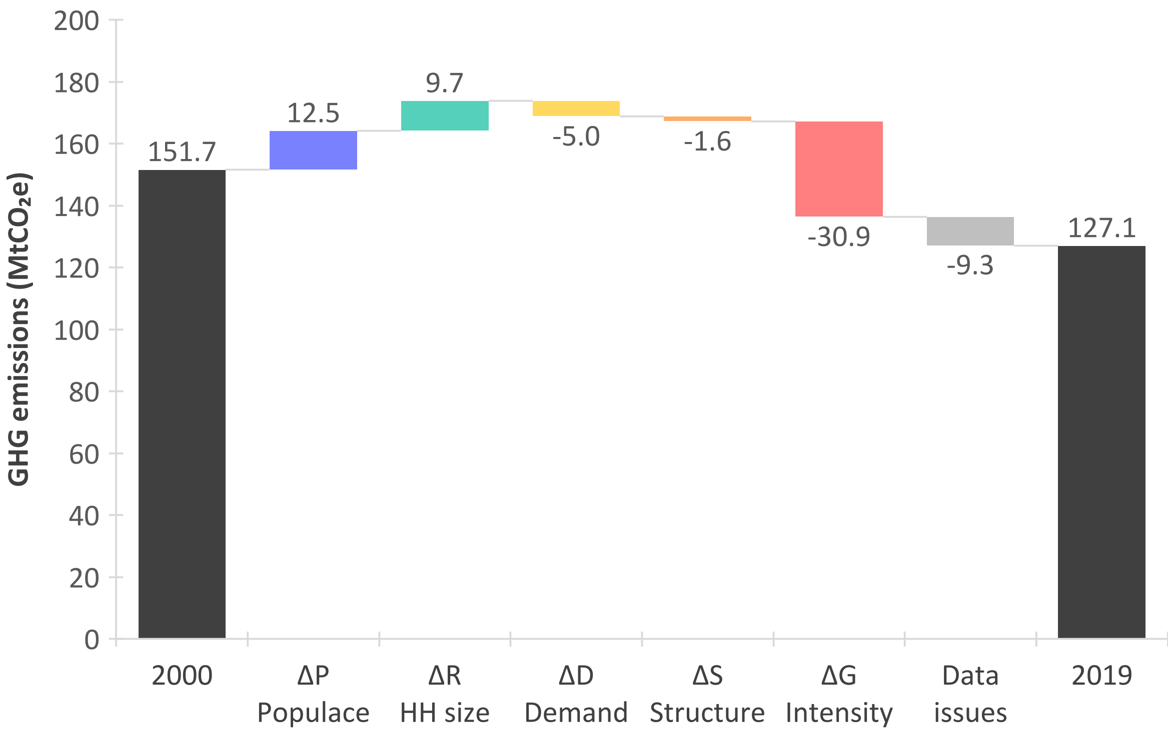
4.2 Decomposition analysis

The overall reduction of household GHG emissions by -24.6 MtCO_2e (or -16.2%) was decomposed into five effects corresponding to the development of the five socio-economic drivers (population, household size, avg. household demand, demand structure, and emission intensity). Figure 9 summarises the outcomes of the decomposition analysis in a waterfall diagram. The initial 151.7 Mt of household GHG emissions were increased by two of the drivers and decreased by three of them. To begin with, the growing number of consumers, measured by population growth (ΔP), contributed to increasing emissions by 12.5 Mt. Simultaneously, the slow but steady shift towards fewer inhabitants per household added another 9.7 Mt (ΔR). Emissions were then reduced by -5.0 Mt (ΔD) as a consequence of Dutch households spent less on average in 2019 than in 2000 (corrected for inflation). Note that these last two effects are interconnected because households becoming smaller also affected how much they spend. The interconnection can be illustrated by imagining that a household with one fewer inhabitant will inherently spend less but still need to be heated, maintained and supplied with energy in much the same way.

As for the structure of demand (ΔS), a slight shift towards less emissive sectors helped decrease emissions by some -1.6 Mt. The majority of reduction were achieved by lowered emission intensities (ΔG), bringing emissions down by as much as -30.9 Mt. A substantial amount of this reductions was realised in two sectors only, energy providers (-7.0 Mt) and the food industry (-6.9 Mt). A detailed analysis of sector contributions, both in terms of demand

Figure 9

Decomposition of household GHG emissions by socio-economic drivers, 2000-2019



structure and emission intensity, is given in Section 4.2.2. On an aggregate level, the remaining -9.3 Mt stems from inconsistencies in the input-output reporting of Statistics Netherlands and therefore was not further reducible (see Section 5.2.3). Overall, a combination of the five effects (and the gap from data issues), made that household GHG emissions were estimated at 127.1 $MtCO_2e$ in 2019.

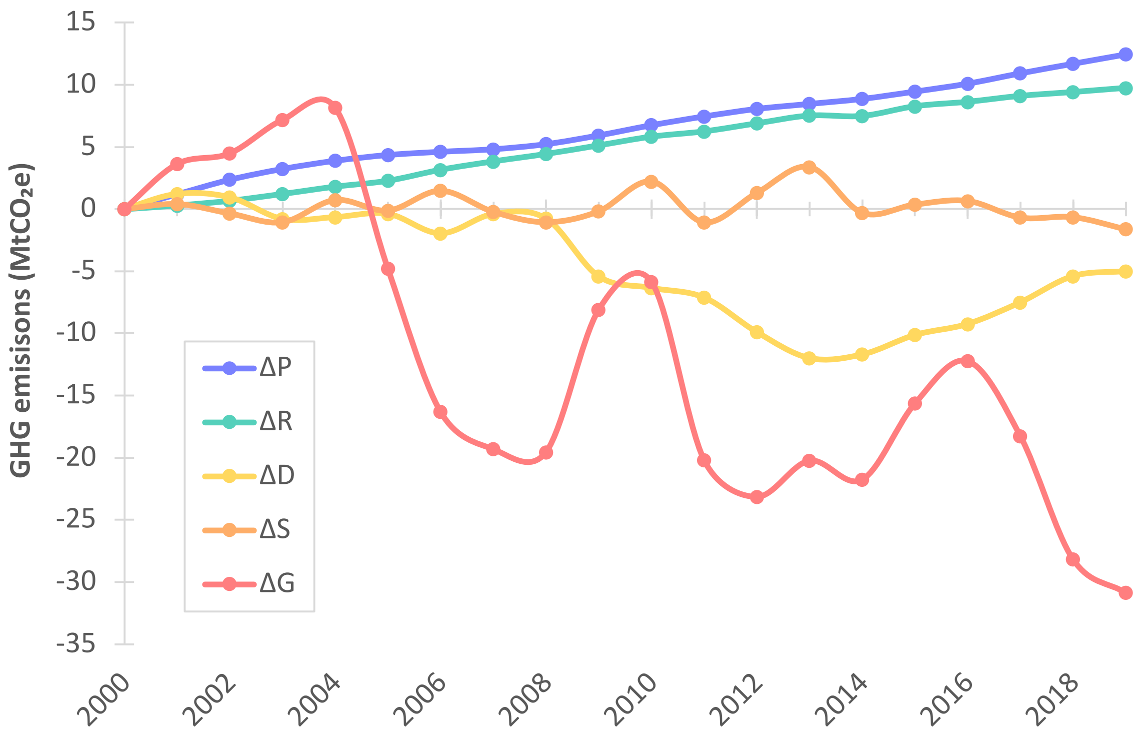
4.2.1 Decomposition by year

The annual development of the five socio-economic indicators and their contributions to changing household GHG emissions are displayed in Figure 10. The effects of demographic indicators population (ΔP) and household size (ΔR) increased at a slow and near-constant rate. They added 12.5 and 9.7 $MtCO_2e$, respectively, in 2019. The structure of consumption, at least on a sector level, stayed largely unvarying, not impacting household GHG emissions by more than a couple of percentages. By 2019, it contributed minimally to reducing household GHG emissions with -1.6 Mt (ΔS).

Emission intensity G was by far the most volatile and, in this sense, influential driver. Observing its development during, for example, the period of global economic crisis 2008-2011, changes in emission intensities were able to sway household GHG emissions by over 10% within a single year. The -16.2% reduction of household GHG emissions from 2000 to 2019 was achieved to the largest extent by emission intensity improvements, contributing some -24.3%. Finally, the effect of household demand (ΔD) was also substantial, reducing emissions by as much as -10% in 2013. Household demand seems to have been influenced by the 2008 economic crisis too, as it stagnated between 2000-2008 and began declining thereafter. The depreciation lasted until 2013 and average household expenditures began gradually increasing again from 2014 onwards. This suggests that the impact of economic recession on household demand is slower and lasts longer than on the emission intensity of consumption.

Figure 10

Cumulative impact of socio-economic drivers on household GHG emissions, 2000-2019

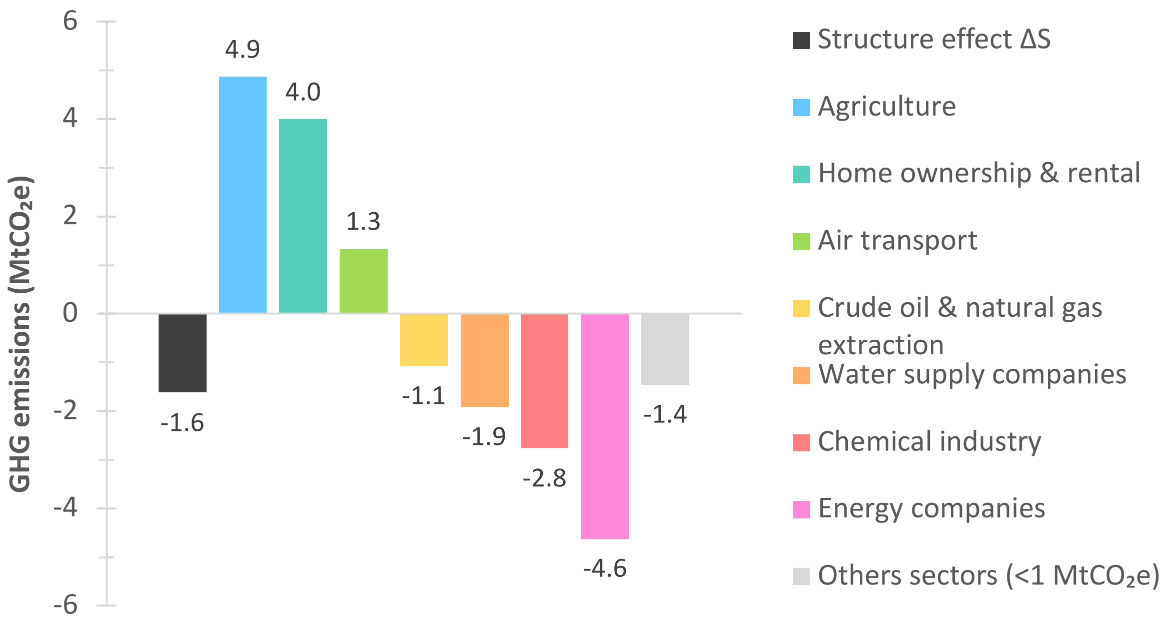


4.2.2 Decomposition by sector

The net emission reductions caused by demand structure and emission intensity changes can be further dissected by economic sectors. Figure 11 shows the demand structure-driven reductions ($\Delta S = -1.6$ $MtCO_2e$) broken down by sectors with the most significant contributions. The increases/decreases of emissions depicted in this figure are attributable to the relatively higher/lower household spendings to these sectors. Household GHG emissions were mostly raised by higher relative expenditures on agriculture (4.9 Mt), house ownership and rental (i.e. permanent accommodation, 4.0 Mt), and air transportation services (1.3 Mt). Simultaneously, the emissions were mainly reduced by relatively lower expenditures on crude oil & natural gas extraction (i.e. fuels, -1.1 Mt), water supply companies (-1.9 Mt), chemical industry (-2.8 Mt) and energy companies (-4.6 Mt). The net effect of demand changes to these seven sectors was, in fact, -0.2 Mt. The rest of the reductions (-1.4 Mt) can be allocated to the other 74 sectors, which each had an influence of less than ±1 Mt individually.

Figure 11

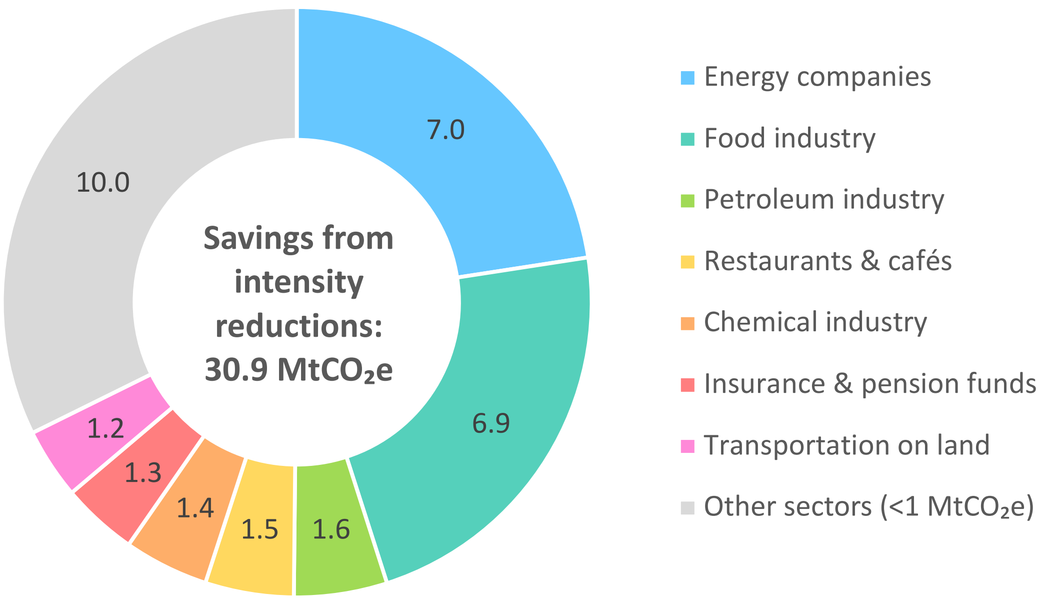
Breakdown of demand structure-driven reductions ΔS into sectors



Finally, Figure 12 presents a breakdown of emission intensity-driven reductions ($\Delta G = -30.9$ MtCO$_2$e), again highlighting the sectors with the greatest influences. Nearly half of these reductions were realised in two sectors only, energy providers (-7.0 Mt) and the food industry (-6.9 Mt). Five more sectors made considerable contributions, which in descending order were the petroleum industry (-1.6 Mt), restaurants and cafés (-1.5 Mt), chemical industry (-1.4 Mt), insurance & pension funds (-1.3 Mt), and land transportation services (-1.2 Mt). Note that the extent to which emission intensity-driven reductions are attributable to production-side improvements as opposed to alterations in consumer preferences that were not captured by ΔS is difficult to tell (see discussion in Section 5.2.2). The other sectors individually had an impact of less than 1 Mt, though their combined net impact reached -10.0 Mt. In contrast, only 14 of the 81 sectors did not see the GHG intensity of their production reduced. The most notable sector here was "crude oil and natural gas extraction activities", which added 0.7 Mt as a result. A complete list of effects by individual sectors can be found in Appendix E.

Figure 12

Breakdown of emission intensity-driven reductions ΔG into sectors



5 Discussion

The discussion chapter is organised into three parts. Section 5.1 compares this research to prior studies and demonstrates how the findings add to existing literature. Section 5.2 deals with the three main limitations identified in this research project. Section 5.3 gives recommendations for how further research could build on this study's findings.

5.1 Contributions to literature

Kerkhof et al. (2009) estimated household GHG emissions at 127 MtCO_2e in 2000, 24 Mt lower than found in this study. The difference is likely to be found in the coverage of emissions. Kerkhof et al. (2009) considered those related to five major consumption categories (food, housing, clothing and footwear, hygiene & medical care, and development, leisure & traffic) and excluded other goods and services (e.g. insurance, social organisations). Although the authors did not provide an explicit reason for this decision, it is assumed to reflect a position that assigning the emissions of these miscellaneous consumption categories presents problems for interpretation. While recognising the issue, this present study incorporated all sectors found in input-output tables, keeping in line with the reasoning that household consumption, from a consumption perspective, gives rise to emissions proportionally to the size of expenditures.

Another estimate of Dutch household GHG emissions in 2000 was provided by Nijdam et al. (2005). They approximated emissions at 175 MtCO_2e, 18 Mt higher than in this study. The difference is probably to be found in a difference in methodology since Nijdam et al. (2005) did not assume Dutch production intensities for all imported goods and services. Instead, they used a multi-regional approach which was able to trace sectoral transactions between four groups of countries (the Netherlands, OECD-Europe, other OECD, and non-OECD).

The literature search did not yield studies that were more relevant to compare as they were either older, focused on countries other than the Netherlands, or considered only CO_2 emissions. Consequently, this study adds to the existing literature in three main aspects as it:

1. Provides an estimate for the GHG emissions from Dutch household consumption more recent than 2000;
2. Presents the development of these emissions over nearly two decades;

3. Breaks the change of emissions down in terms of contributions by socioeconomic drivers.

5.2 Limitations

5.2.1 Dutch intensities proxy for imported goods and services

One of the most important limitations is related to the treatment of imported goods and services, both for final and intermediate consumption. Determining the emissions associated with production occurring abroad is immensely complicated because one needs to consider many countries with interdependent economies. Instead of completely excluding household expenditures for imported goods and services, the study simply assumed the same GHG intensity for productions taking place domestically and abroad. This shortcut, however, means that household GHG emissions were misestimated to some degree. The size of the error is difficult to even approximate but observing the countries exporting the most to the Netherlands might give an impression of its direction. In 2019, nearly half of the imports (49.7%) were covered by five countries, which were Germany (€79 billion), Belgium (€45 billion), China excl. Hong Kong (€43 billion), the United States (€37 billion), and the United Kingdom (€25 billion) (Statistics Netherlands, 2022b). While the precise emissions embedded in these international trades are not readily available and would require another analysis to estimate, the WRI's Climate Watch publishes the GHG emissions per unit of GDP for each of these countries. Their figures were either comparable (Germany 187 gCO_2e/USD, Belgium 203 gCO_2e/USD, the United Kingdom 152 gCO_2e/USD) or higher (China 844 gCO_2e/USD, United States 269 gCO_2e/USD) than the specific GHG emissions of the Netherlands (191 gCO_2e/USD) (World Resources Institute, 2022). This suggests that assuming uniform emission intensities for goods and services produced domestically and abroad likely resulted in an underestimation of household GHG emissions.

5.2.2 Lower emission intensities not equivalent to production-side improvements

The second major limitation concerned the possible misinterpretation of two of the drivers. Following prior studies, the indicator 'demand structure' S was introduced to measure what sorts of goods and services households spent their money on. The naming of this indicator, however, may give the reader the impression that it is a measurement of consumption patterns, which is not precisely the case. Demand structure S, as defined in this study, is suitable to record shifts in consumption spendings *between* sectors. It is not able to detect changes *within* sectors, which are instead contained in changing emission intensities. Consequently, lower emission intensities comprise both production-side improvements (e.g. higher efficiencies) as well as demand-side changes (e.g. new consumption practices). Interpreting emission-intensity driven reductions requires careful consideration to avoid over-/underestimating the causes that brought them about. Further research is necessary to understand the exact underlying factors of emission intensity changes.

5.2.3 Unexplained emission reductions purely statistical

Finally, a considerable amount of emission reductions (9.3 Mt) remained unexplained in terms of the five socio-economic drivers. The imbalance originates in the accounting methodology that Statistics Netherlands used for constructing input-output tables. In 2018, they published a revision to the complete Dutch National Accounts and accordingly updated most of the related datasets backwards until 1995. As for input-output tables, the revision was only applied to 2015 and from then onwards, meaning that I/O tables for 2000-2014 were only available with the older methodology (this was confirmed by consulting CBS). The new methodology introduced several changes to I/O tables, including an extension to the set of economic sectors that describe the structure of the economy. The number of sectors increased from 76 to 81 as four of them were subdivided into two or more new sectors. The most significant split was applied to house rental and ownership, which category represents the largest expense for households on average. These expenses were previously counted together with other real estate services under “Real estate rental and trade services”. According to the new methodology, the cost of home ownership is now accounted for separately under “Imputed rental value of owner-occupied properties”, while house rentals remain categorised together with other real estate rentals under “Real estate services other than owner-occupied property”. The division has a major implication for house ownership, which is now seen as a special sector that produces for its own final use, i.e. does not sell to other sectors (European Parliament, 2013, p.83). Note that house rental does not sell to other sectors either (i.e. individuals do not sublet their homes to companies) but it is inseparable from rental services that do so. The intermediate separation of house ownership, constituting the largest expense for households, into a service without output to other sectors caused a major disruption in the estimation of emissions and is responsible for a large part of the 9.3 Mt imbalance.

The rest of the gap is explained by slight adjustments in the values of intra- and inter-sectoral transactions between the two methodologies. For example, agriculture-to-agriculture transactions in 2015, the first entry of both tables, were estimated 13% higher, from €4.6 billion to €5.2 billion, in the old and the new methodologies. Such variations, in combination with the separation of house ownership from rental services, produced the 9.3 Mt drop in household GHG emissions. As a result, the imbalance can be interpreted as entirely statistical, which does not correspond to actual emission mitigations. While the inter-sectoral monetary flows are too complex to tune, an attempt could be made to ensure house ownership is dealt with more consistently across the years and therefore reduce the gap in emission estimates. The corrected household GHG emissions for 2015-2019 would likely be higher (or 2000-2014 values lower) than at present, though a certain level of mismatch would still prevail due to the issues with inter-sectoral transactions.

5.3 Future research

The findings of this study may be refined or extended by further research. Four potential improvements are identified below. Three of them relate to the study's main limitation discussed earlier, while the fourth one gives suggestions for expanding the scope of analysis to gain additional insights.

1. The limitation concerning the use of Dutch emission intensities as proxies for production taking place abroad may be overcome by the use of multi-regional EEIO (or EEMRIO) analysis. This technique combines the input-output tables of multiple countries, thereby allowing the tracing of emission sources across countries. EEMRIO analysis would not only lead to more accurate estimations of household GHG emissions but also provide insights into where the emissions occur. When applied to Swedish consumption, Schmidt et al. (2019) revealed that the reduction of domestic emissions between 1995-2014 was met with an increase of emissions abroad.

2. The correct interpretation of emission intensity-driven reductions requires additional investigation. As the reduction of a sector's emission intensities is the outcome of many factors, an economy-wide analysis is complicated to carry out. Instead, sectors may be best analysed individually by using, for example, Index Decomposition Analysis as suggested by Su and Ang (2012).

3. The decomposition of household GHG emissions could be improved by minimising the amount of unexplained emissions. Since they mainly originated from the intermediate change in the treatment of house ownership in statistics, an attempt could be made to alter the input-output tables such that it is uniformly handled throughout the years.

4. This study examined the GHG emissions of Dutch household consumption from a national average perspective. Much difference is likely to exist among various household types. Further research could expand on the findings of this paper by analysing the expenditures of household (and their associated GHG emissions) across additional dimensions, such as locality (e.g. urban/rural, provincial), income distribution, household size, and other relevant indicators. A more nuanced understanding of household GHG emissions could aid the design of future climate policies by providing insights into how they would affect the different household types.

6 Conclusion

This research aimed to provide insight into the relationship between climate change and household consumption in the Netherlands. The research question was ”How are changes in Dutch household consumption-driven GHG emissions explained by changes in social, economic and environmental drivers during the period 2000-2019?” Based on a quantitative analysis of the development of five socioeconomic drivers between 2000-2019, it can be concluded that population, household size and the emission intensity of consumption had the most impact on household GHG emissions. The results indicated that the eventual -24.6 $MtCO_2e$ reduction of these emissions can be mostly attributed to lower emission intensities (-30.9 Mt), while population growth and a tendency towards smaller households counterbalanced them by adding 12.5 and 9.7 Mt each. The influences of household demand and its composition were found to be smaller albeit still significant as they contributed to reducing household GHG emissions by -5.0 and -1.6 Mt. Note that household demand declined as a result of decreased household size, while the net increase of individual expenditures in fact added 4.7 Mt to household GHG emissions. Despite the methodology’s precision, an emission reduction of 9.3 Mt remained unexplained due to inconsistencies in data reporting. As for policy implications, the findings underline the importance of emission intensity reduction. The mitigations achieved this way have increasingly outpaced the growth of Dutch household consumption in the past two decades. Simultaneously, this study also highlighted the powerful role of population growth in offsetting the GHG emission mitigations accomplished otherwise. While demographic developments remain a complicated policy matter, prospective climate policies should recognise the significance of these factors and address them in the best possible way to optimise GHG emission reductions.

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Appendix A

Economic sectors in the Dutch National Accounts

Table A1

Economic sectors in input-output tables

Code	Methodology 2000-2015	Code	Methodology 2015-2019
S1	Agriculture	T1	Agriculture
S2	Forestry	T2	Forestry
S3	Fisheries	T3	Fisheries
S4	Extraction of crude petroleum and natural gas	T4	Extraction of crude petroleum and natural gas
S5	Mining and quarrying (excluding oil and gas)	T5	Other mining and quarrying (excluding oil and gas)
S6	Food industry	T6	Support activities for mineral extraction
S7	Beverage industry	T7	Food industry
S8	Tobacco industry	T8	Beverage industry
S9	Textile, clothing, leather industry	T9	Tobacco industry
S10	Wood industry	T10	Textile, clothing, leather industry
S11	Paper industry	T11	Wood industry
S12	Graphics industry	T12	Paper industry
S13	Petroleum industry	T13	Graphics industry
S14	Chemical industry	T14	Petroleum industry
S15	Pharmaceutical industry	T15	Chemical industry
S16	Rubber and plastic products industry	T16	Pharmaceutical industry
S17	Building materials industry	T17	Rubber and plastic products industry
S18	Basic metal industry	T18	Building materials industry
S19	Metal products industry	T19	Basic metal industry
S20	Electrical engineering industry	T20	Metal products industry
S21	Electrical equipment industry	T21	Electrical engineering industry

S22	Machine industry	T22	Electrical equipment industry
S23	Car and trailer industry	T23	Machine industry
S24	Other transport equipment industry	T24	Car and trailer industry
S25	Furniture industry	T25	Other transport equipment industry
S26	Other manufacturing	T26	Furniture industry
S27	Repair and installation of machinery	T27	Other manufacturing
S28	Energy companies	T28	Repair and installation of machinery
S29	Water supply companies	T29	Energy companies
S30	Sewerage, waste management and remediation	T30	Water supply companies
S31	General construction and project development	T31	Sewerage, waste management and remediation
S32	Earth, water and road construction	T32	General construction and project development
S33	Specialised construction	T33	Earth, water and road construction
S34	Car trade and repair	T34	Specialised construction
S35	Wholesale and commission trade	T35	Car trade and repair
S36	Retail trade (not in motor vehicles)	T36	Wholesale and commission trade
S37	Land transport	T37	Retail trade (not in motor vehicles)
S38	Water transport	T38	Land transport
S39	Air transport	T39	Water transport
S40	Warehousing, services for transport	T40	Air transport
S41	Postal and courier services	T41	Warehousing, services for transport
S42	Accommodation	T42	Postal and courier services
S43	Restaurants and cafes	T43	Accommodation
S44	Publishing	T44	Restaurants and cafes
S45	Film, TV and radio	T45	Publishing
S46	Telecommunications	T46	Motion picture, TV, radio and music production

S47	IT services	T47	Broadcasting of radio and television programmes
S48	Information services	T48	Telecommunications
S49	Banking	T49	IT services
S50	Insurance and pension funding	T50	Information services
S51	Other financial services	T51	Banking
S52	Real estate rental and trade services	T52	Insurance and pension funding
S53	Legal and accounting services	T53	Other financial services
S54	Holding companies and management consultancies	T54	Imputed rental value of owner-occupied dwellings
S55	Architectural and engineering activities and related activities	T55	Real estate services other than owner-occupied property
S56	Research	T56	Legal and accounting services
S57	Advertising and market research	T57	Holding companies and management consultancies
S58	Design, photography and translation services	T58	Architectural and engineering activities and related activities
S59	Veterinary services	T59	Research
S60	Hire of movable property	T60	Advertising and market research
S61	Employment agency services	T61	Design, photography and translation services
S62	Travel agency, tour operator and travel information	T62	Veterinary services
S63	Security and investigation services	T63	Hire of movable property
S64	Cleaning companies, gardeners etc.	T64	Employment agency services
S65	Other business services	T65	Travel agency, tour operator and travel information
S66	Public administration and government services	T66	Security and investigation services

S67	Education	T67	Cleaning companies, gardeners etc.
S68	Health care	T68	Other business services
S69	Care and welfare	T69	Public administration and government services
S70	Arts, culture and gambling	T70	Education
S71	Sport and recreation	T71	Health care
S72	Idealistic, interest-, and hobby associations	T72	Care and welfare
S73	Repair of consumer goods	T73	Creative, arts and entertainment services
S74	Other personal service activities	T74	Libraries, archives, museums etc.
S75	Households with employed persons	T75	Gambling and betting services
S76	Goods and services n.e.c.	T76	Sport and recreation
		T77	Activities of intellectual, professional and hobby associations
		T78	Repair of personal and household goods
		T79	Other personal service activities
		T80	Activities of households with employed persons
		T81	Goods and services n.e.c.

Appendix B

Defining consumption domains

Consumption domain	Sector code	Sector name
Nutrition	S1/T1	Agriculture
	S3/T3	Fisheries
	S6/T7	Food industry
	S7/T8	Beverage industry
	S8/T9	Tobacco industry
	S43/T44	Restaurants and cafes
Housing	S4/T4	Extraction of crude petroleum and natural gas
	S5/T5	Other mining & quarrying (excluding oil & gas)
	T6	Support activities for mineral extraction
	S10/T11	Wood industry
	S17/T18	Building materials industry
	S18/T19	Basic metal industry
	S20/T21	Electrical engineering industry
	S25/T26	Furniture industry
	S28/T29	Energy companies
	S29/T30	Water supply companies
	S30/T31	Sewerage, waste management and remediation
	S31/T32	General construction and project development
	S33/T34	Specialised construction
	S52/T54	Net rental value of owner-occupied dwellings
	T55	Real estate services other than owner-occupied property
	S64/T67	Cleaning companies, gardeners, etc.
Mobility	S13/T14	Petroleum industry
	S23/T24	Car and trailer industry
	S24/T25	Other transport equipment industry

	S34/T35	Car trade and repair
	S37/T38	Land transport
	S38/T39	Water transport
	S39/T40	Air transport
	S40/T41	Warehousing, services for transport
Consumer goods	S9/T10	Textile, clothing, leather industry
	S11/T12	Paper industry
	S12/T13	Graphics industry
	S14/T15	Chemical industry
	S15/T16	Pharmaceutical industry
	S16/T17	Rubber and plastic products industry
	S19/T20	Metal products industry
	S21/T22	Electrical equipment industry
	S22/T23	Machine industry
	S26/T27	Other manufacturing
	S32/T33	Earth, water and road construction
	S35/T36	Wholesale trade and commission trade
	S36/T37	Retail trade (not in motor vehicles)
Leisure	S2/T2	Forestry
	S42/T43	Accommodation
	S45/T46	Film, TV, radio & music production
	T47	Broadcasting of radio & TV programmes
	S62/T65	Travel agency, tour operator and travel information
	S70/T73	Creative, arts and entertainment services
	T74	Libraries, archives, museums and the like
	T75	Gambling and betting services
	S71/T76	Sport and recreation
	S72/T77	Intellectual, professional & hobby associations
Services	S27/T28	Repair and installation of machinery

S41/T42	Postal and courier services
S44/T45	Publishing
S46/T48	Telecommunications
S47/T49	IT services
S48/T50	Information services
S49/T51	Banking
S50/T52	Insurance and pension funding
S51/T53	Other financial services
S53/T56	Legal and accounting services
S54/T57	Holding companies and management consultancies
S55/T58	Architectural and engineering services
S56/T59	Research
S57/T60	Advertising and market research
S58/T61	Design, photography and translation services
S59/T62	Veterinary services
S60/T63	Hire of movable property
S61/T64	Employment agency services
S63/T66	Security and investigation services
S65/T68	Other business services
S66/T69	Public administration and government services
S67/T70	Education
S68/T71	Health care
S69/T72	Care and welfare
S73/T78	Repair of personal and household goods
S74/T79	Other personal service activities
S75/T80	Activities of households with employed persons
S76/T81	Goods and services n.e.c.

Appendix C

Mapping of GHG emissions to sectors

This appendix describes how sectoral emissions were mapped to input-output table sectors. S- and T-codes refer to the identification of sectors; see Appendix A. When a category was mapped to a single sector (e.g. S9), the emissions were directly coupled to that sector. For categories with multiple sectors indicated (e.g. S1-S3), the emissions were split proportionally over those sectors, i.e. proportional to the final consumption expenditures on the sectors in input-output records.

Table C1

Mapping of GHG emissions to economic sectors

Code	Category name	Method 2000-2015	Method 2015-2020
E1	Transport activity by private households	S37-39	T38-40
E2	Other private households	S1-76	T1-81
E3	Agriculture, forestry and fishing	S1-3	T1-3
E4	Mining and quarrying	S4-5	T4-6
E5	Manufacture of food and beverages	S6-8	T7-9
E6	Man. of textile-, leatherproducts	S9	T10
E7	Manufacture of wood products	S10	T11
E8	Manufacture of paper	S11	T12
E9	Printing and reproduction	S12	T13
E10	Manufacture of coke and petroleum	S13	T14
E11	Manufacture of chemicals	S14	T15
E12	Manufacture of pharmaceuticals	S15	T16
E13	Manufacture rubber, plastic products	S16	T17
E14	Manufacture of building materials	S17	T18
E15	Manufacture of basic metals	S18	T19
E16	Manufacture of metal products	S19	T20
E17	Manufacture of electronic products	S20	T21

E18	Manufacture of electric equipment	S21	T22
E19	Manufacture of machinery n.e.c.	S22	T23
E20	Transport equipment	S23-24	T24-25
E21	Other manufacturing and repair	S25-27	T26-28
E22	Electricity and gas supply	S28	T29
E23	Water supply and waste management	S29-30	T30-31
E24	Construction	S31-33, S76	T32-34, T81
E25	Wholesale and retail trade	S34-36	T35-37
E26	Land transport	S37	T38
E27	Water transport	S38	T39
E28	Air transport	S39	T40
E29	Warehousing, services for transport	S40	T41
E30	Postal and courier activities	S41	T42
E31	Accommodation and food serving	S42-43	T43-44
E32	Information and communication	S44-48	T45-50
E33	Financial institutions	S49-51	T51-53
E34	Renting, buying, selling real estate	S52	T54-55
E35	Other specialised business services	S53-59	T56-62
E36	Renting & other business support	S60-65	T63-68
E37	Public administration and services	S66	T69
E38	Education	S67	T70
E39	Health and social work activities	S68-69	T71-72
E40	Culture, sports and recreation	S70-72	T73-77
E41	Other service activities	S73-74	T78-79
E42	Activities of households	S75	T80
E43	Extraterritorial organisations	N/A	N/A

Appendix D

Mapping of household expenditures to sectors

Code	Expenditure category	Code	Economic sector
C1	Potatoes, fruit and vegetables	-	Sum of C1-C6 was split proportionally among Agriculture (S1/T1), Fisheries (S3/T3) and Food industry (S6/T7)
C2	Meat and meat products	-	
C3	Fish	-	
C4	Dairy, eggs, oils and fats	-	
C5	Bread, bread products, pastry & cakes	-	
C6	Groceries	-	
C7	Non-alcoholic beverages	S7/T8	Beverage industry
C8	Alcoholic beverages	S7/T8	Beverage industry
C9	Tobacco	S8/T9	Tobacco industry
C10	Clothing and textiles	S9/T10	Textile, clothing, leather industry
C11	Shoes and leather goods	S9/T10	Textile, clothing, leather industry
C12	Furnishings and home decoration	S10/T11	Wood industry
		S11/T12	Paper industry
		S17/T18	Building materials industry
		S25/T26	Furniture industry
C13	Electrical equipment	S20/T21	Electrical engineering industry
		S21/T22	Electrical equipment industry
C14	Transport equipment	S23/T24	Car and trailer industry
		S24/T25	Other transport equipment industry

		S34/T35	Car trade and repair
C15	Other durable goods	S12/T13	Graphics industry
		S16/T17	Rubber and plastic products industry
		S18/T19	Basic metal industry
		S19/T20	Metal products industry
		S22/T23	Machine industry
		S31/T32	General construction and project development
		S32/T33	Earth, water and road construction
		S33/T34	Specialised construction
C16	Energy and water	S28/T29	Energy companies
		S29/T30	Water supply companies
		S30/T31	Sewerage, waste management and remediation
C17	Motor fuels	S4/T4	Extraction of crude petroleum and natural gas
		S13/T14	Petroleum industry
C18	Personal care products	S14/T15	Chemical industry
		S15/T16	Pharmaceutical industry
C19	Other goods	S2/T2	Forestry
		S5/T5	Other mining and quarrying (excluding oil and gas)
		T6	Support activities for mineral extraction
		S26/T27	Other manufacturing
		S35/T36	Wholesale trade and commission trade
		S36/T37	Retail trade (not in motor vehicles)
C20	Actual rent	S52/T54-55	Real estate services other than owner-occupied property

C21	Imputed rental value own dwelling	S52/T54-55	Imputed rental value of owner-occupied dwellings
C22	Services related to house and garden	S60/T63	Hire of movable property
		S64/T67	Cleaning companies, gardeners, etc.
C23	Food and beverage service	S43/T44	Restaurants and cafes
C24	Accommodation	S42/T43	Accommodation
C25	Recreational services	S62/T65	Travel agency, tour operator and travel information
		S71/T76	Sport and recreation
		S72/T77	Intellectual, professional and hobby associations
C26	Cultural services	S70/T73	Creative, arts and entertainment services
		T74	Libraries, archives, museums and the like
		T75	Gambling and betting services
C27	Transport services	S37/T38	Land transport
		S38/T39	Water transport
		S39/T40	Air transport
		S40/T41	Warehousing, services for transport
		S41/T42	Postal and courier services
C28	Communication services	S44/T45	Publishing
		S45/T46	Motion picture, TV, radio and music production
		T47	Broadcasting of radio and television programmes
		S46/T48	Telecommunications
		S47/T49	IT services

		S48/T50	Information services
C29	Medical services	S68/T71	Health care
C30	Welfare services	S69/T72	Care and welfare
C31	Financial and business services	S49/T51	Banking
		S50/T52	Insurance and pension funding
		S51/T53	Other financial services
		S53/T56	Legal and accounting services
		S54/T57	Holding companies and management consultancies
		S55/T58	Architectural and engineering activities and related activities
		S56/T59	Research
		S57/T60	Advertising and market research
		S58/T61	Design, photography and translation services
		S59/T62	Veterinary services
		S61/T64	Employment agency services
		S63/T66	Security and investigation services
		S65/T68	Other business services
C32	Other services	S27/T28	Repair and installation of machinery
		S66/T69	Public administration and government services
		S67/T70	Education
		S73/T78	Repair of personal and household goods
		S74/T79	Other personal service activities
		S75/T80	Activities of households with employed persons
		S76/T81	Goods and services n.e.c.

Appendix E

Consumption-based emissions and intensities of sectors

Code	Economic sector	Emissions 2000 ($MtCO_2e$)	Emissions 2019 ($MtCO_2e$)	Intensity 2000 (gCO_2e/€)	Intensity 2019 (gCO_2e/€)
	Total/Average	151.70	127.14	516	383
S1/T1	Agriculture	4.50	10.07	1700	1576
S2/T2	Forestry	0.03	0.01	1095	1035
S3/T3	Fisheries	0.11	0.02	1075	1013
S4/T4	Extraction of crude petroleum and natural gas	0.91	0.39	270	442
S5/T5	Other mining and quarrying (excluding oil and gas)	0.01	0.00	263	340
T6	Support activities for mineral extraction	-	0.00	-	314
S6/T7	Food industry	33.48	29.78	1273	978
S7/T8	Beverage industry	0.89	0.58	181	112
S8/T9	Tobacco industry	0.96	0.57	126	128
S9/T10	Textile, clothing, leather industry	2.06	1.51	145	83
S10/T11	Wood industry	0.08	0.24	101	209
S11/T12	Paper industry	1.05	0.82	324	209
S12/T13	Graphics industry	0.16	0.02	94	39
S13/T14	Petroleum industry	5.90	5.36	772	526
S14/T15	Chemical industry	6.91	4.45	1206	955
S15/T16	Pharmaceutical industry	0.04	0.09	109	50
S16/T17	Rubber and plastic products industry	0.12	0.48	113	121
S17/T18	Building materials industry	0.29	0.25	528	346

S18/T19	Basic metal industry	0.36	0.22	1267	1039
S19/T20	Metal products industry	0.44	0.37	417	359
S20/T21	Electrical engineering industry	0.24	0.23	82	28
S21/T22	Electrical equipment industry	0.03	0.10	77	52
S22/T23	Machine industry	0.15	0.07	180	135
S23/T24	Car and trailer industry	0.08	0.02	69	55
S24/T25	Other transport equipment industry	0.13	0.03	98	63
S25/T26	Furniture industry	0.84	0.72	97	76
S26/T27	Other manufacturing	0.02	0.01	72	57
S27/T28	Repair and installation of machinery	0.03	0.04	147	233
S28/T29	Energy companies	30.98	22.40	4064	3132
S29/T30	Water supply companies	2.89	1.41	921	996
S30/T31	Sewerage, waste management and remediation	0.45	0.79	1149	1309
S31/T32	General construction and project development	0.26	0.38	579	568
S32/T33	Earth, water and road construction	0.00	0.00	233	249
S33/T34	Specialised construction	0.62	0.37	319	358
S34/T35	Car trade and repair	2.37	1.41	198	135
S35/T36	Wholesale trade and commission trade	3.18	2.13	512	394
S36/T37	Retail trade (not in motor vehicles)	0.67	0.54	296	245

S37/T38	Land transport	3.93	3.24	1069	767
S38/T39	Water transport	0.36	0.18	1460	1128
S39/T40	Air transport	1.80	4.23	1625	1646
S40/T41	Warehousing, services for transport	0.05	0.05	228	186
S41/T42	Postal and courier services	0.19	0.18	352	306
S42/T43	Accommodation	0.92	1.07	211	159
S43/T44	Restaurants and cafes	6.78	4.94	322	236
S44/T45	Publishing	0.16	0.06	108	52
S45/T46	Motion picture, TV, radio and music production	0.02	0.01	69	28
T47	Broadcasting of radio and television programmes	-	0.01	-	25
S46/T48	Telecommunications	0.90	0.38	179	77
S47/T49	IT services	0.02	0.08	78	82
S48/T50	Information services	0.00	0.01	15	31
S49/T51	Banking	1.49	0.26	167	70
S50/T52	Insurance and pension funding	2.61	2.39	202	135
S51/T53	Other financial services	0.01	0.02	40	36
S52/T54	Imputed rental value of owner-occupied dwellings	16.36	9.38	357	212
T55	Real estate services other than owner-occupied property	-	4.09	-	222
S53/T56	Legal and accounting services	0.15	0.16	88	63
S54/T57	Holding companies and management consultancies	0.00	0.03	175	196

S55/T58	Architectural and engineering activities and related activities	0.00	0.00	78	63
S56/T59	Research	0.00	0.00	34	27
S57/T60	Advertising and market research	0.00	0.00	90	45
S58/T61	Design, photography and translation services	0.01	0.00	53	25
S59/T62	Veterinary services	0.02	0.04	76	66
S60/T63	Hire of movable property	0.59	0.41	138	107
S61/T64	Employment agency services	0.00	0.00	74	66
S62/T65	Travel agency, tour operator and travel information	2.07	0.91	361	202
S63/T66	Security and investigation services	0.00	0.00	48	51
S64/T67	Cleaning companies, gardeners, etc.	0.26	0.29	120	107
S65/T68	Other business services	0.00	0.01	79	81
S66/T69	Public administration and government services	4.52	2.94	600	450
S67/T70	Education	0.67	0.82	134	135
S68/T71	Health care	1.88	1.21	219	153
S69/T72	Care and welfare	0.95	0.76	212	160
S70/T73	Creative, arts and entertainment services	0.47	0.07	181	80
T74	Libraries, archives, museums and the like	-	0.03	-	64

T75	Gambling and betting services	-	0.29	-	133
S71/T76	Sport and recreation	0.72	0.83	188	153
S72/T77	Activities of intellectual, professional and hobby associations	0.04	0.04	74	66
S73/T78	Repair of personal and household goods	0.12	0.12	160	118
S74/T79	Other personal service activities	2.38	1.71	271	186
S75/T80	Activities of households with employed persons	0.00	0.00	8	1
S76/T81	Goods and services n.e.c.	0.00	0.00	70	47