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The Impact of Demographic Change on Energy Use and Greenhouse Gas Emissions

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Executive Summary

This paper estimates the impact of demographic change on energy use and GHG emissions in Germany. Because of differences in age-specific consumption patterns, the ageing of the population affects the direct energy use and GHG emissions of households. The shift in the structure of consumption expenditure in turn affects the energy use and GHG emissions of production sectors via the industrial backward linkages. The impact on consumption structures is modelled on the basis of consumption survey (EVS) data and household projections up to the year 2030. The resulting vectors of final demand are entered into an environmental input-output model, which allows the estimation of energy use and GHG emissions. The model results suggest that demographic change has a relatively small effect on overall energy use and GHG emissions, but a significant reallocation between energy sources can be observed.

Keywords

Demographic change, energy, emissions, input-output

Contribution to

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I Introduction

Demographic change is a process which results from increasing life expectancies coupled with low birth rates and manifests itself in an ageing and, in many cases, shrinking population. In Germany, for example, the number of births has been lower than the number of deaths every single year since 1972, which means that without immigration, Germany's population would have been shrinking since that time [Tivig & Hetze, 2007]. Since the total fertility rate (births per woman) shows no signs of reaching the reproduction level of 2.1 in the foreseeable future, the number of births is projected to continue falling over the coming decades, and the share of persons aged 65 years or more is projected to grow from 19 percent in 2005 to 29 percent in 2030 [Statistisches Bundesamt, 2007]. Similar developments can be observed in most of the other economically advanced countries. In 2004, for example, the total fertility rate was 1.33 in Italy, 1.29 in Japan, 1.74 in the United Kingdom, and 1.66 in the OECD countries as a whole [The World Bank, 2006]. Furthermore, Tivig and Hetze [2007] argue that demographic change is only the latest phase in a demographic transition which started in Europe around the middle of the 19th century, and that all countries will eventually undergo a similar process. Thus, the demographic change in Germany seems to be the rule rather than the exception.

It seems natural to suspect that a profound transformation of a nations' demographic structure may have serious impacts on the economy. For the most part, economists have addressed worries about the sustainability of pay-as-you-go pension systems, arguing that as demographic change increases the number of pensioners relative to the number of people of working, these systems may face trouble. Bofinger [2004] and others argue that these worries tend to be of little substance since the increase in the overall dependency ratio – the ratio of children *and* pensioners to persons of working age – will be far less pronounced. Therefore, economists have recently begun to focus on other aspects of demographic change. Distelkamp et al. [2004], and Buslei et al. [2007], for instance, discuss the impact of demographic change on the structure of consumption expenditures. Dewhurst [2006] goes one step further and estimates how a demographically induced shift in consumption expenditures affects sectoral production, using a regional input-output model for Scotland, while Park and Hewings [2007] and Yoon and Hewings [2006] investigate the economic impact of demographic change using an econometric model of the Chicago region.

The present paper deals with another possibly important effect of demographic change. Its aim is to find out whether demographic change will help advanced economies like Germany to reduce greenhouse gas (GHG) emissions, which is an important policy objective given the potentially disastrous effects of climate change. The motivation for this study lies in the observation that people of different age groups differ considerably in their consumption patters. For example, old people tend to consume more heat energy and less gasoline than young people because they tend to be more sensitive to cold and to use cars less frequently because impaired vision and hearing make driving more difficult. Thus, by increasing the share of old people in the total population, demographic change may affect the use of different energy sources, which in turn will probably affect GHG emissions. A recent study by Dalton et al. [2008] supports the hypothesis that demographic change affects GHG emissions. According to their calculations, demographic change reduces carbon dioxide (CO2) emissions in the US by 40 percent between 2000 and 2100.

In order to find out whether the results by Dalton et al. [2008] can be generalised to other countries and other types of GHG emissions, the paper at hand investigates the impact of demographic change on energy use and emissions of three distinct greenhouse gases in Germany. To this end, data from a household survey of income and expenditure (*Einkommens- und Vermögensstichprobe* – henceforth EVS) are used to identify age-specific consumption patterns and to assess the impact of demographic change, which follows the household projections by Kühntopf and Tivig [2007], on the structure of consumption expenditure. A projection of consumption expenditures is entered into an environmental input-output (EIO) model to estimate the impact of the demographically induced shift in consumption expenditures on sectoral production, energy use and GHG emissions. The results indicate that up to the year 2030, the effects of demographic change on overall energy use and emissions in Germany are limited.

The paper is structured as follows. In Section II, data from the environmental-economic accounts are used to identify the sectors which are responsible for most of the energy use and GHG emissions in Germany. The sectors thus identified receive further attention in the subsequent discussion. In Section III, data from the EVS are used to identify age-specific consumption patterns, with a focus on energy consumption. Section IV provides an exposition of the methodology including the consumption projection and the EIO model. The results from the model calculations are presented in Section V. Finally, Section VI concludes.

II Energy Use and Greenhouse Gas Emissions in Germany

If the aim of a study is to find out how a particular event, in this case demographic change, affects energy use and emission in Germany, it is necessary to know where energy is currently used, and where emission currently arise. Therefore, this section describes current patterns of energy use, identifying certain production sectors and consumption categories which are responsible for major parts of energy use and emissions. In so doing, it draws mainly on two sources: the German environmental-economic accounts [Statistisches Bundesamt, 2006] and a study by Schoer et al. [2006]. The *relevant* sectors and consumption categories thus identified will receive further attention in the subsequent analyses.

In 2005, total energy use of the German economy amounted to 25,003 petajoules. The major part of this, 19,064 petajoules, was used by the production sectors, and private households used another 3,766 petajoules. Thus, households and production sectors accounted for 22,831 petajoules or 91 percent of total energy use. Another 1,922 petajoules of energy were exported. The remainder of 250 petajoules consisted of transmission losses, changes in stocks, and 'statistical errors'. In this paper, we concentrate on *domestic energy use*, which we define as the sum of energy use by private households and production sectors. We neglect energy exports because they are mostly driven by global market forces and not by German demographic developments and ignore the remainder because of its negligible size.

Energy used by...	PJ	%
Private households and production sectors	22,831	100.0
Private households	3,766	16.5
Production sectors	19,064	83.5
Refined petroleum products and other fuels (CPA 23)	6,319	27.7
Refined petroleum products (CPA 23.1)	5,939	26.0
Production and distribution of energy (CPA 40)	5,972	26.2
Production and distribution of electricity (CPA 40.1)	5,588	24.5
Chemical products (CPA 24)	1,343	5.9
Basic metals (CPA 27)	901	3.9
Basic iron and steel and ferro-alloys (CPA 27.1)	737	3.2

Source: Statistisches Bundesamt [2006]

Table 1: Major energy users in Germany (2005)

Table 1 shows a breakdown of German domestic energy use in 2005. Among the production sectors, which were responsible for 83.5 percent of domestic energy use, two homogeneous branches stand out as the major users of energy: *refined petroleum products* and *production and distribution of electricity* together make up more than 50 percent of domestic energy use. Other important users of energy are the producers of *chemical products* and *basic metals*. Thus, private households along with a handful of production sectors were the relevant energy users in 2005.

Commodity groups containing energy	PJ	%
Total	3992	100.0
Products of forestry, logging etc. (CPA 02)	187	4.7
Coal and peat (CPA 10)	43	1.1
Crude petroleum and natural gas (CPA 11)	1081	27.1
Refined petroleum products and other fuels (CPA 23)	2014	50.0
Electricity and district heat (CPA 40.1 and 40.3)	659	16.5
Other commodity groups	8	0.2

Source: Schoer et al. [2006]

Table 2: Energy use of households by commodity group (2003)

Table 2 shows how the energy used by households can be allocated to different commodity groups according to Schoer et al. [2006][1]. Interestingly, half of the direct energy use by households can be attributed to *refined petroleum products and other fuels*. Since ‘other fuels’ means, in this context, coke oven products and nuclear fuels, which are rarely used by households, we may as well drop the ‘other fuels’ part and talk of refined petroleum products instead. Thus, refined petroleum products, which include gasoline as well as heating oil, make up half of private households’ energy use. This means that if demographic change affects the use of these fuels, and Section II suggests that this is quite likely, it will have a serious impact on households’ overall energy use.

Another important share (27.1 percent) of households’ direct energy use is allocated to the commodity group *crude petroleum and natural gas*. Since households rarely consume crude petroleum, this actually means ‘natural gas’. The next largest share of 16.5 percent is allocated to *electricity and district heat*[2]. Further energy use is allocated to the sectors *products of forestry, logging etc.* (i. e. firewood) and *coal and peat*. The remainder of eight petajoules is negligible.

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[1] Note that the data provided by Schoer et al. refers to the year 2003, whereas Table 1 refers to the year 2005. Therefore, the totals are not consistent.

[2] Since district heat is usually produced in cogeneration plants, it is very difficult to disentangle the production of district heat and electricity. Therefore, many publications do not differentiate between the two and allocate them to one commodity group ‘electricity and district heat’.

Domestic emissions of	CO_2	CH_4	N_2O
Total	201,129 Kt	132,624 t	3,783 t
Private households	22.9 %	5.4 %	1.8 %
Production sectors	77.1 %	94.6 %	98.2 %
Agriculture and hunting (CPA 01)	1.0 %	45.1 %	63.7 %
Coal and peat (CPA 10)	0.2 %	13.4 %	0.1 %
Chemical products (CPA 24)	3.5 %	0.0 %	20.1 %
Other non-metallic mineral products (CPA 26)	5.3 %	0.1 %	0.3 %
Production and distribution of energy (CPA 40)	41.7 %	8.7 %	6.2 %
Electricity (CPA 40.1)	38.2 %	0.2 %	5.7 %
Gases (CPA 40.2)	0.0 %	8.5 %	0.0 %
District heat (CPA 40.3)	3.5 %	0.0 %	0.4 %
Other production sectors	25.4 %	27.3 %	7.8 %

Source: Statistisches Bundesamt [2006]

Table 3: Major emission sources (2005)

Aside from energy use, this paper is also concerned with greenhouse gas emissions. Therefore, Table 3 shows total emissions of three such gases, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide or laughing gas (N_2O), as well as a breakdown of those emissions over the main emission sources. One of the most important findings from Table 3 is that different greenhouse gas emissions originate from different sources. For example, the most important source of CO2 emissions is the production and distribution of energy (41.7 percent), whereas the most important source of CH4 and N20 emissions is agriculture and hunting (which is responsible for 45.1 percent of CH4 and 63.7 percent of N2O emissions. However, although greenhouse gas emissions stem from different sources, they are highly concentrated – According to Table 3, private households and a handful of production sectors are responsible for almost three quarters of CO2 and CH4 emissions and more than 90 percent of N20 emissions. Private households are an important source (22.9 percent) of CO2 emissions, but their role in CH4 and N2O emissions is very small.

Private households' emissions of	CO_2	CH_4	N_2O
Total	207,063 Kt	81,532 t	3,967
Products of forestry, logging etc. (CPA 02)	0.0 %	27.6 %	7.4 %
Coal and peat (CPA 10)	1.4 %	4.5 %	4.0 %
Crude petroleum and natural gas (CPA 11)	29.2 %	57.5 %	8.4 %
Refined petroleum products & other fuels (CPA 23)	69.3 %	10.4 %	80.2 %
Other commodity groups	0.0 %	0.0 %	0.0 %

Source: Statistisches Bundesamt [2006]

Table 4: Greenhouse gas emissions of private households (2003)

The greenhouse gas emissions originating from private households are allocated to individual commodity categories in Table 4. The data show that all of these emissions arise from the burning of fuels, which explains the close connection between energy policy and climate policy. However, burning different types of fuels generates different types of emissions. For example, the consumption of products of forestry, logging etc. (i. e. firewood) generates almost no CO2 emissions, but it is responsible for 27.6 percent of households' CH4 emissions and 7.4 percent of households' N20 emissions.

Table 4 underlines the importance of the distinction between direct and indirect emissions. For example, the *consumption* of electricity by private households does not cause any direct emissions (which is the reason for it not appearing in Table 4), but the *production* of electricity does, according to Table 3. Therefore, a study of the impact of demographic change cannot focus exclusively on the consumption of private households. It has to take the indirect effects into account, which arise through the interindustry linkages.

III Age-Specific Consumption Patterns

The analysis in the previous section has shown that private households account for a significant share of greenhouse gas emissions directly, but most of these emissions are caused by production sectors. However, production sectors only produce if there is demand for their output. Therefore, a change in demand for a certain commodity has an effect on the output level of the sector producing that commodity, and even if the consumption of this commodity does not generate any emissions, its production may very well do so. Thus, demographic change may affect emissions not only via households' consumption of energy commodities but also via their consumption of other goods. Therefore, this section provides an overview over households' expenditure over all consumption categories, although energy naturally remains an area of special interest.

Since old people have different needs than young people, they consume different types of goods and services. The consumption behaviour of households from different age groups in Germany can be studied using data from the EVS, in which more than 50,000 German households report their consumption expenditure on 133 distinct categories of goods and services. The classification of consumption expenditure is based on SEA, the German implementation of the international COICOP standard. The calculations shown in this section were carried out using the scientific use files of the EVS, which offer a differentiation by 133 consumption categories (Table A1).

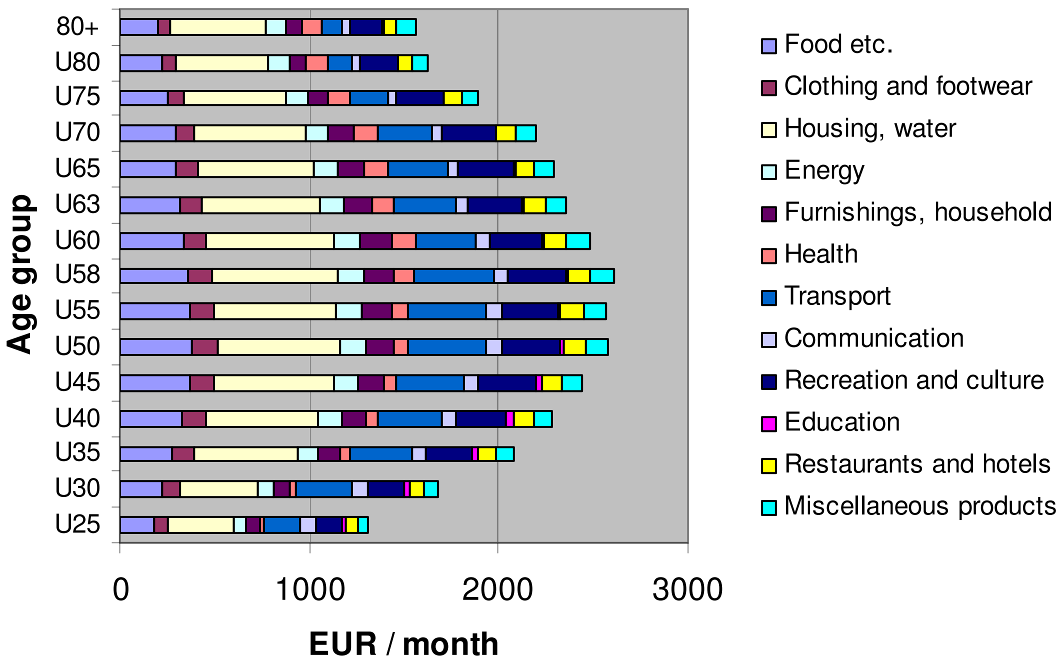
Consumption purpose	Share (%)
Food, beverages, tobacco and narcotics	13.9
Clothing and footwear	5.1
Housing, water	26.4
Energy	5.5
Furnishings, household	5.8
Health	3.9
Transport	14.0
Communication	3.2
Recreation and culture	12.0
Education	0.9
Restaurants and hotels	4.6
Miscellaneous goods and services	4.6

Source: author's calculations based on EVS 2003 data

Table 5: Consumption expenditures of the average household in 2003

In order to place the analysis in a more general context, Table 5 shows the general distribution of household consumption expenditures over 12 broader consumption categories. The average household spends 2178 Euros per month. Table 1 shows that the largest consumption category was housing and water (26.4 percent), followed by transport (14.0 percent), food etc. (13.9 percent) and recreation and culture (12.0 percent). Energy as a consumption purpose accounts for 5.5 percent of total consumption expenditure[3].

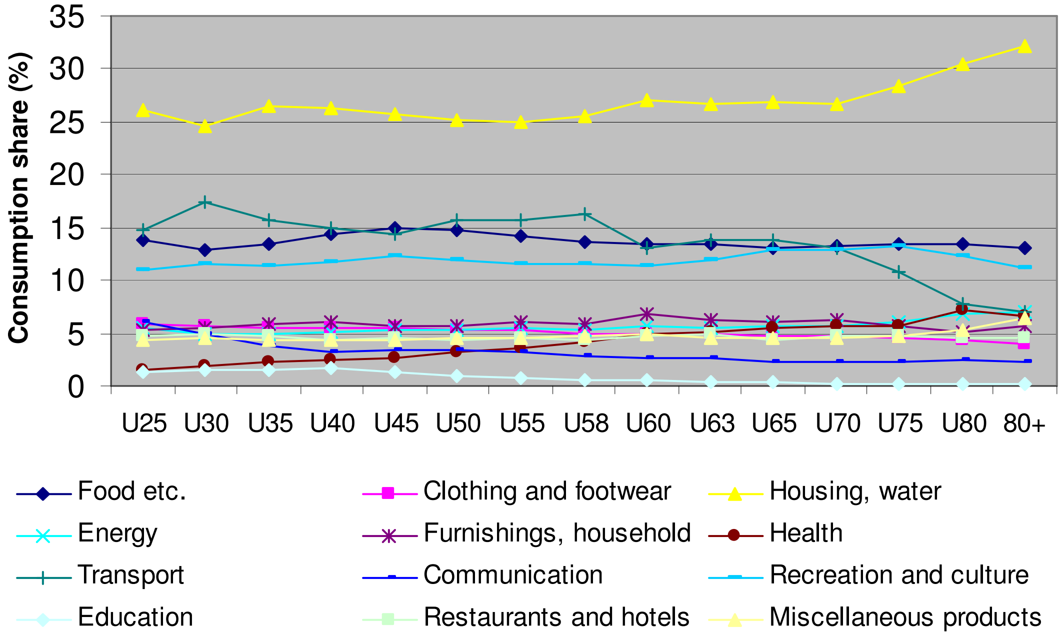
[3] It should be noted, however, that the consumption purpose 'energy' does not contain the gasoline used in cars. Since consumer expenditures are classified by consumption *purpose*, gasoline is included under 'transport'.



Source: author's calculations

Figure 1: Composition of consumption expenditures in different age groups

Since we are interested in the effects of demographic change, we have to look at the differences between households in different age groups. As distinguishing characteristic, we use the age of the household's main income earner. Figure 1 shows the composition of consumption expenditures in households by age group, where U25 means 'younger than 25', U30 means 'between 25 and 29 years' and so on. A glance at Figure 1 reveals that the amount of consumption expenditure differs considerably among age groups. In general, the relationship between household age and consumption expenditure is hill-shaped. The lowest consumption expenditure is observed for households of the youngest age group (under 25 years), which spend only 1,310 Euros per month on average. Middle-aged households, whose main income earner is between 55 and 57 years old, spend 2,607 Euros per month on average, more than any other age group. Households of the oldest age group (80 years and older) spend 1,562 Euros on average, slightly more than the youngest households but significantly less than the middle-aged households.

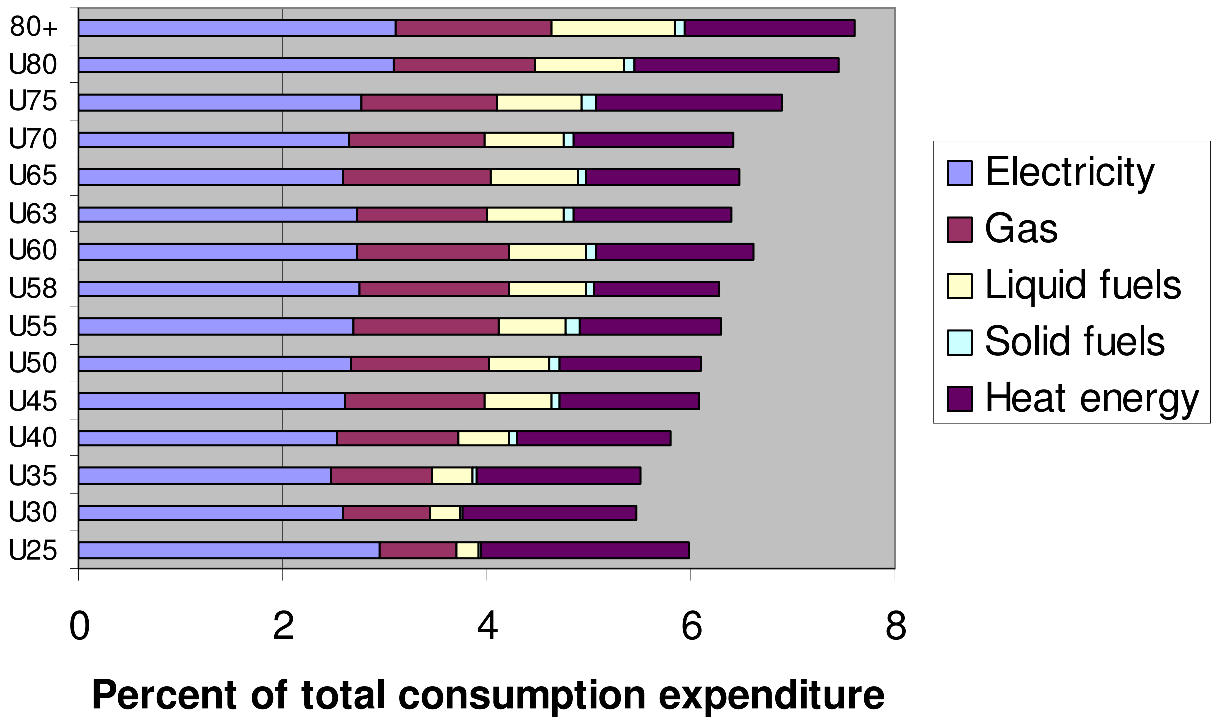


Source: author's calculations

Figure 2: Relationship between household age and consumption coefficients

More interesting than the total amount of consumption expenditure, however, is the distribution of that expenditure over the individual consumption purposes. One can see from Figure 1 already that the share of transport, for example, decreases with age, whereas the share of health increases. The development of these consumption shares can be seen more clearly in Figure 2. That figure shows that the shares of some consumption purposes differ considerably among households of different age groups. For the purposes of the present paper, it is important to note that the share of energy is clearly higher for households in the age groups above 75 years, whereas the share of transport is substantially lower among older households. This observation suggests that demographic change may cause an increase in the demand for energy infrastructure and a decrease in the demand for transport infrastructure.

Figure 3 provides a more detailed perspective of the rather broad consumption category 'energy', distinguishing between electricity, gas, liquid fuels, solid fuels and heat energy. It confirms our previous assertion that older households tend to allocate a larger share of their total consumption expenditure to energy – the total share of energy increases from less than six percent in the younger age groups to almost eight percent in the oldest age group. One interesting observation is that the general increase in the share of energy is not reflected in every single type of energy consumed. This is probably related to the different geographical situation of young and old households. It is likely that a significant share of the younger households lives in rented apartments situated in urban and metropolitan areas, where heat energy is quite common[4]. Older households, by contrast, tend to live in rural areas, where heat energy is less common; and many of them are likely to own a house with a heating that runs on liquid fuels (oil). Therefore, it seems natural that older households consume much more liquid fuels than young households.



Source: author's calculations

Figure 3: Consumption shares of different types of energy

To sum up the observations of this section, there are significant differences in the structure of consumption expenditures among households of different age groups. Notably, older households tend to spend relatively less money on transport and more on energy. Furthermore, older households tend to consume different types of energy than young households. Therefore, it is likely that demographic change, which increases the share of older households in the total population, will have an effect on the structure of consumption expenditures.

Thus, we should expect that demographic change will affect the economy through the channel of final demand. It will have a direct impact on the structure of final demand by households. Naturally, this direct impact will be followed by all sorts of indirect effects which work their way backward through the production chains until they affect the markets for primary production factors such as labour, capital, and energy. Hence, demographic change will affect future energy use and GHG emissions in two

[4] The distribution of heat energy is relatively more profitable in densely populated areas. Therefore, it is more common in urban areas than in rural areas.

ways, first by affecting the direct energy use and emissions of households, followed by indirect effects affecting the energy use and emissions of the production sectors. A comprehensive analysis of the economic impact of demographic change must therefore take both its direct and indirect effects into account. An established framework for analysing direct and indirect effects of a change in final demand is the input-output model developed by Wassily Leontief and others. The application of this model to the problem at hand is discussed in the following section.

IV Modelling the Impact of Demographic Change

The conclusion from the previous section is that households from different age groups differ greatly in their consumption patterns, and therefore demographic change is likely to affect energy use and GHG emissions. However, as argued above, in order to acquire a complete picture of the impact of demographic change on energy consumption and emissions, we need to take account of the direct and indirect effects. One way to do this is to apply an environmental input-output (EIO) model for Germany.

The input-output model in the tradition of Leontief is essentially a demand-driven model. Therefore, it forms a suitable framework for analysing the effects of demographically induced changes in final demand. For this purpose, we proceed in three steps. First, we calculate a projection of final demand by households, depending on demographic developments. This projection is based on the household projections by Kühntopf and Tivig [2007]. The next step is to convert the consumption projection, in which consumption expenditure is classified by *consumption purposes*, into *commodity groups*. Finally, the projection of households' consumption expenditure by commodity group is entered into the EIO model, which makes it possible to evaluate the development of sectoral production, energy use, and emissions. The following sections describe the methodology in more detail.

IV.1 Projection of private consumption

In order to differentiate between older and younger households, all households are sorted into different *age groups*, depending on the age of the households' main income earner. The number of different age groups is denoted by $\tilde{g}$. For simplicity, we assume that households within each age group are homogeneous. Thus, rather than differentiating households further according to the number of household members, household income or other characteristics, we assume an 'average' household for each age group.

Total consumption expenditure by an 'average' household of age group g amounts to

(1) $$c_g = (1 - s_g) y_g ,$$

where s_g stands for the saving rate and y_g stands for the net income of a household in age group g.

The total consumption expenditure of a household is differentiated by different consumption purposes, and the number of different purposes is $\tilde{m}$. For each consumption purpose m, a consumption coefficient γ_g^m is defined as $\gamma_g^m = c_g^m / c_g$. This represents the share of consumption purpose m in total consumption expenditure. Thus, the total consumption expenditure of a household from age group g may be written as:

(2) $$c_g^m = \gamma_g^m c_g$$

Since we assume homogeneity within each age group by postulating a hypothetical 'average' household, we can calculate the total consumption expenditure of age group g on consumption purpose m by multiplying c_g^m with the number of households H_g:

(3) $$C_g^m = H_g c_g^m$$

The total expenditure for a consumption purpose m can then be determined by summing over all age groups:

(4) $$C^m = \sum_{g=1}^{\tilde{g}} C_g^m$$

The sum of private consumption expenditure at the macroeconomic level is:

(5) $$\overline{C} = \sum_{m=1}^{\tilde{m}} C^m$$

Equations (1) to (4) may be used to derive the following expression for consumption expenditure by consumption purpose:

$$(6) \qquad C^m = \sum_{g=1}^{\tilde{g}} H_g \gamma_g^m (1 - s_g) y_g$$

As equation (6) shows, the total consumption expenditures by consumption purpose depend on the number of households H_g, the consumption coefficients γ_g^m, the savings rate s_g, and net income y_g. Any change in these parameters leads to a change in consumption expenditures. In the present paper, we isolate the impact of demographic change by keeping γ_g^m, s_g and y_g constant[5]. For H_g, we substitute the values from the household projections by Kühntopf and Tivig [2007], as described above.

During the practical application of this procedure, an annoying problem arises, because types of consumption expenditure are notoriously underreported in the EVS household survey, for example the expenditures on cigarettes and drinks consumed in bars and pubs. In order to solve this problem, we follow the recommendation by Lehmann [2004], who suggests to calculate coverage ratios (*Deckungsquoten*) for each consumption purpose category. Based on the input-output tables of 2003[6], we calculate for each consumption purpose category m a *coverage ratio* CR_m. If this coverage ratio is equal to one, an estimation based on EVS data yields exactly the same result as the official national accounts. If it is smaller (larger) than one, an estimation based on EVS data leads to an underestimation (overestimation) of the official figure. We assume that CR_m does not change over time and divide our consumption projection for each commodity group by CR_m. As a result, we end up with a projection of consumption expenditures corrected for EVS reporting errors.

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[5] Although there are good reasons for believing that demographic change will have effects on these variables as well, those effects are outside the scope of the present paper, which focuses exclusively on the impact of differing consumption structures.

[6] The most recent EVS was conducted in 2003. Therefore, if we wish to estimate the coverage ratio, we have to compare the EVS data with the input-output tables from the same year.

IV.2 Conversion into commodity groups

During the collection of the EVS data, the respondents allocate their consumption expenditure to different consumption purposes[7]. In the national input-output tables, however, products are allocated to different commodity groups[8]. Therefore, we have to convert our consumption projection into commodity groups to ensure compatibility with the input-output tables. This conversion can be achieved using the *consumption allocation table* published by the Federal Statistical Office (FSO).

The core of this table is formed by an allocation matrix V, whose structure is shown in Table 6. In this matrix, the consumption expenditure for different consumption purposes (columns) is allocated to different commodity groups (rows). For example, column 1 may contain the expenditure on consumption purpose 'food' (SEA code 011), and row 1 may contain the commodity group 'products of agriculture, hunting and forestry' (CPA code 01). In this case, the value in cell $V_{1,1}$ tells us how many products of agriculture, hunting and forestry (measured in monetary units, i. e. Euros) were bought by household for use as food. The consumption allocation table presented here identifies n different commodity groups and $\tilde{m}$ different consumption purposes. Thus, it consists of n rows and $\tilde{m}$ columns.

Consumption expenditure of private households by…		consumption purpose			
		1	2		$\tilde{m}$
commodity group	1	$V_{1,1}$	$V_{1,2}$	$\cdots$	$V_{1,\tilde{m}}$
	2	$V_{2,1}$	$V_{2,2}$	$\cdots$	$V_{2,\tilde{m}}$
	$\vdots$	$\vdots$	$\vdots$		$\vdots$
	n	$V_{n,1}$	$V_{n,2}$	$\cdots$	$V_{n,\tilde{m}}$

Table 6: The consumption allocation matrix

In its publications, the FSO usually augments the actual allocation matrix V by including one additional row and column. In this extended table, row $n+1$ contains the sum of expenditures on the respective consumption purposes, while column $\tilde{m}+1$ contains the sum of expenditures on the respective commodity groups (Table 7). In order to prevent misunderstandings, we denote the total expenditure for a consump-

[7] The different consumption purposes are defined following the SEA classification, the German version of the international COICOP standard (see Appendix).

[8] The different commodity groups are defined following the CPA classification (see Appendix). Since some of these groups have awfully long names, we use shorter names in the text. For example, the official heading of CPA category 11 is 'crude petroleum and natural gas; services incidental to oil and gas extraction, excluding surveying', but for the sake of legibility we refer to it simply as 'crude oil and natural gas' in the text.

tion purpose by C^m, where the superscript m identifies the consumption purpose, and total expenditure for a commodity group by C_i, where the subscript i identifies the commodity group.

Consumption expenditure of private households by…		consumption purpose				
		1	2	…	$\tilde{m}$	Sum
commodity group	1	$V_{1,1}$	$V_{1,2}$	…	$V_{1,\tilde{m}}$	C_1
	2	$V_{2,1}$	$V_{2,2}$	…	$V_{2,\tilde{m}}$	C_2
	⋮	⋮	⋮		⋮	⋮
	n	$V_{n,1}$	$V_{n,2}$	…	$V_{n,\tilde{m}}$	C_n
	Sum	C^1	C^2	…	$C^{\tilde{m}}$	$\overline{C}$

Table 7: Augmented consumption allocation matrix

We define a vector C containing total consumption expenditures by commodity groups:

$$(7) \qquad C = (C_1,...,C_n)$$

As Table 7 shows, each element of C can be calculated by summing over the entries in the corresponding column of V :

$$(8) \qquad C_i = \sum_{m=1}^{\tilde{m}} V_{i,m}$$

In order to perform the conversion, we define a *consumption allocation coefficient* $v_{i,m}$ as:

$$(9) \qquad v_{i,m} \equiv \frac{V_{i,m}}{C^m}$$

The most recent consumption allocation table of the FSO is based on data from the year 2004. From these data, we calculate consumption allocation coefficients according to (9). In the following, we assume that these coefficients do not change over time[9].

From (6), we have a projection of C^m. Re-arranging (9) then allows us to calculate a projection of $V_{i,m}$:

$$(10) \quad V_{i,m} = v_{i,m} C^m$$

Using (10) in (8) yields:

$$(11) \quad C_i = \sum_{m=1}^{\tilde{m}} v_{i,m} C^m$$

Equation (11) yields a projection of private consumption expenditure by commodity groups, which is what we need to put into the open Leontief model in step 3. Before we can actually proceed, however, we have to resolve another minor problem: the EVS consumption expenditures are expressed in consumer prices, whereas the input-output tables are available only in producer prices. In order to solve this problem, we use a table containing additional information (trade margins and commodity taxes for each commodity group) which the FSO provided to us upon request. This table makes it possible, under certain assumptions, to convert consumer prices into producer prices, which is what we need to proceed.

IV.3 Projection of Sectoral Production

Our projection of households' consumption expenditures refers only to the final use of products by households, which makes up only part of the total use of products. Another important component of total use consists of *intermediate use*. In 2004, total consumption expenditures of private households amounted to roughly 1,100 billions of Euros, whereas intermediate use amounted to almost 2,000 billions of Euros. Therefore, an analysis of private consumption can only yield an incomplete picture. In order to account for the ultimate impact of the demand-induced effects of demographic change on total energy use, the indirect effects must be taken into consideration as well. For example, the aforementioned consumption projection may show that

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[9] We are not arguing that the assumption of time-invariant consumption coefficients is realistic. However, it is a useful assumption at this point because our focus is on the purely demographically induced change in the structure of consumption expenditures. We are planning to devote more attention to the development of the consumption coefficients in future work.

demographic change causes an increase in the consumption expenditures on 'health'. This observation, although interesting, does not tell us anything about the required use of energy or the associated emissions.

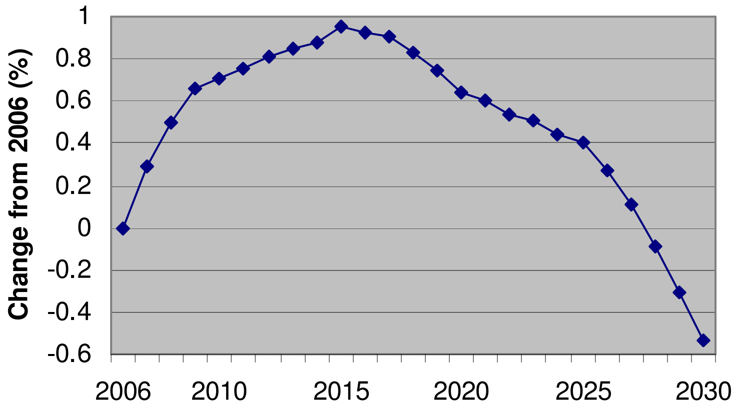
This is the point where input-output analysis comes into play. We use an open static Leontief model for impact analysis. Using this model, one can estimate how the individual production sectors react to a given change in final demand. A detailed description of the impact analysis approach in an open static Leontief model is provided, for instance, by Miller and Blair [1985].

Impact analysis allows the estimation of indirect demand-induced effects. In the aforementioned example (an increase in spending on health-related products), one may assume that the output of the sector 'pharmaceuticals products' (CPA code 24.4) will increase. In order to increase its output, this sector has to use more inputs. Thus, the delivering sectors must raise their output levels as well. In this fashion, the initial demand impulse sends successive waves of intermediate demand through the linkages between production sectors, until finally a new equilibrium is reached and total demand can be satisfied. This mechanism can be analysed in the demand-driven input-output model.

However, our main goal is not to produce a projection of sectoral output, but to estimate the impact of demographic change on energy use and emission. In order to project energy use and emission by private households and firms, we first calculate energy and emission intensities using data from the environmental-economic accounts and the input-output accounts. Next, assuming that these energy and emission intensities remain constant over time, we compute a projection of energy use and emissions. The result of this exercise is an estimate of the impact of demographic change on energy use and emissions in Germany.

V Findings

The data presented in Table 2 and Table 4 shows that all of the greenhouse gas emissions and nearly all of the direct energy use of private households can be traced back to the consumption of energy commodities. Therefore, rather than presenting the entire projection of consumption expenditure by 133 consumption purposes or 71 commodity groups, the following discussion focuses on the consumption of these commodities. Similarly, it would be impractical to present the development of sectoral output for all 71 production sectors. Therefore, the most relevant production sectors, which are identified in Table 1 and Table 3, will be in the focus of the discussion.



Source: author's calculations

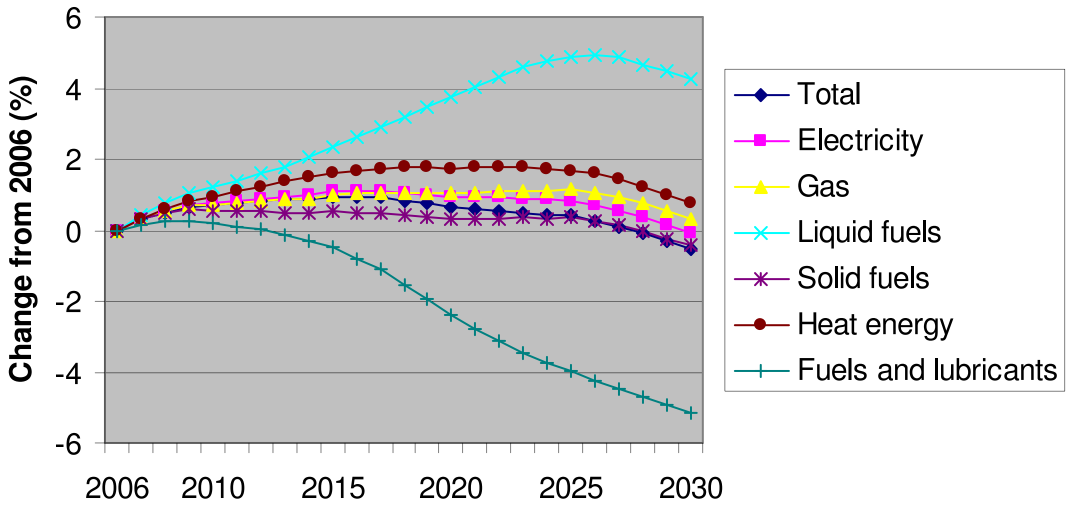
Figure 5: Impact on total consumption expenditure

First of all, however, it is important to be aware of the fact that in our projection of households' consumption expenditures, the amount of aggregate consumption expenditure is not held constant. Rather, the amount of consumption expenditure per household is held constant in each age group. Since the number of households changes, the amount of aggregate consumption expenditure also changes. According to Figure 5, it grows quickly from 2006 to 2009, then more slowly. In the year 2015, aggregate consumption expenditure reaches a peak, lying almost one percent above its initial value. After that, it falls slowly, returning to its initial value between 2026 and 2027 and falling quickly until the end of the simulation period, when it lies roughly 0.6 percent below its initial value. This does not mean, however, that we are actually predicting a reduction in total consumption expenditure. It only means that demographic change has a negative impact on total consumption expenditure after 2026.

Figure 6 shows how demographic change affects the consumption expenditures on six different types of energy[10]. A glance at the figure reveals that the different types of energy are affected in very different ways. Demographic change has a large positive effect on the consumption of liquid fuels, raising it by roughly five percent between 2006 and 2026. These are fuels that are mainly used for heating purposes. The consumption of heat energy (i. e. district heat and charges for central heating in buildings with multiple apartments) is also increased. These observations seem reasonable, considering that old people tend to prefer higher temperatures and pensioners spend more time at home than people of working age. Thus, demographic change increases the consumption of energy used for heating purposes. On the other hand, however, the consumption of fuels and lubricants for motor vehicles is considerably

[10] The EVS data also lists consumption expenditures on 'ice used for cooling purposes', but these are extremely low and therefore not further discussed in this paper.

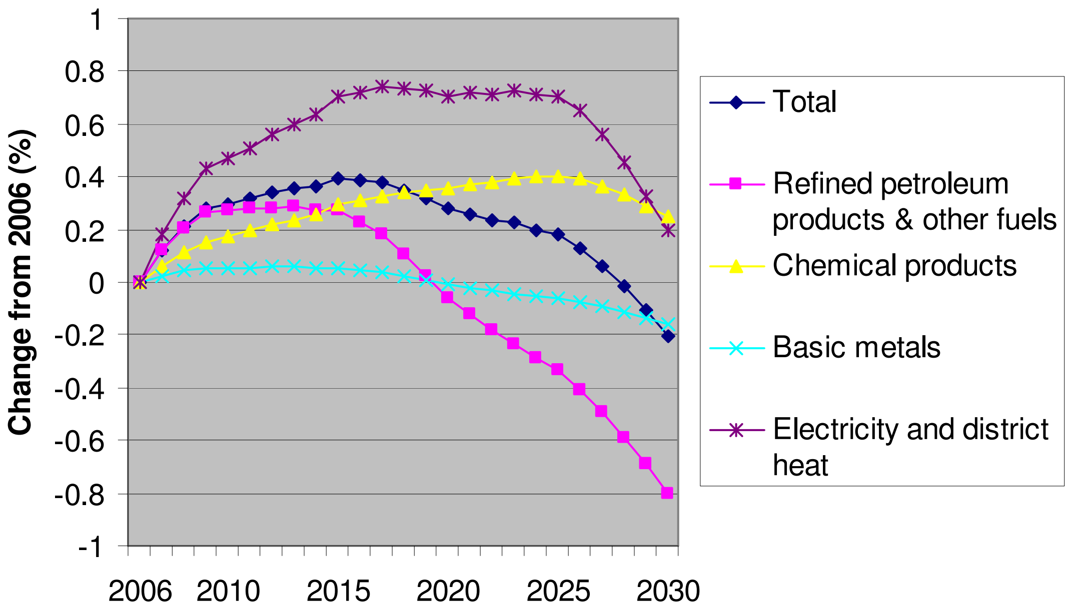
reduced, as shown in Figure 6. The reason for this is that old people tend to use cars less frequently for a variety of reasons, for example because pensioners do not have to commute. Thus, our calculations suggest that the impact of demographic change on aggregate energy consumption expenditure is relatively small, but within the energy sector there is a reallocation between different energy sources, which tends to reduce the consumption of motor vehicle fuels and to increase the consumption of energy used for heating purposes.



Source: author's calculations

Figure 6: Consumption expenditure on energy

Furthermore, the projection of consumption expenditures shows that demographic change has a significant impact on many types of expenditures, most notably in the areas of health and education. For example, expenditure on care services is increased by more than 20 percent, and expenditure on hospital services is increased by almost 15 percent. By contrast, expenditure on child care is reduced by nearly 20 percent and expenditure on private lessons is reduced by about 16 percent. Although developments are very interesting, however, they are not directly related to energy use and emissions, so they receive no further attention at this point. Instead, we now turn to the impact of demographic change on sectoral output, energy use and emissions.

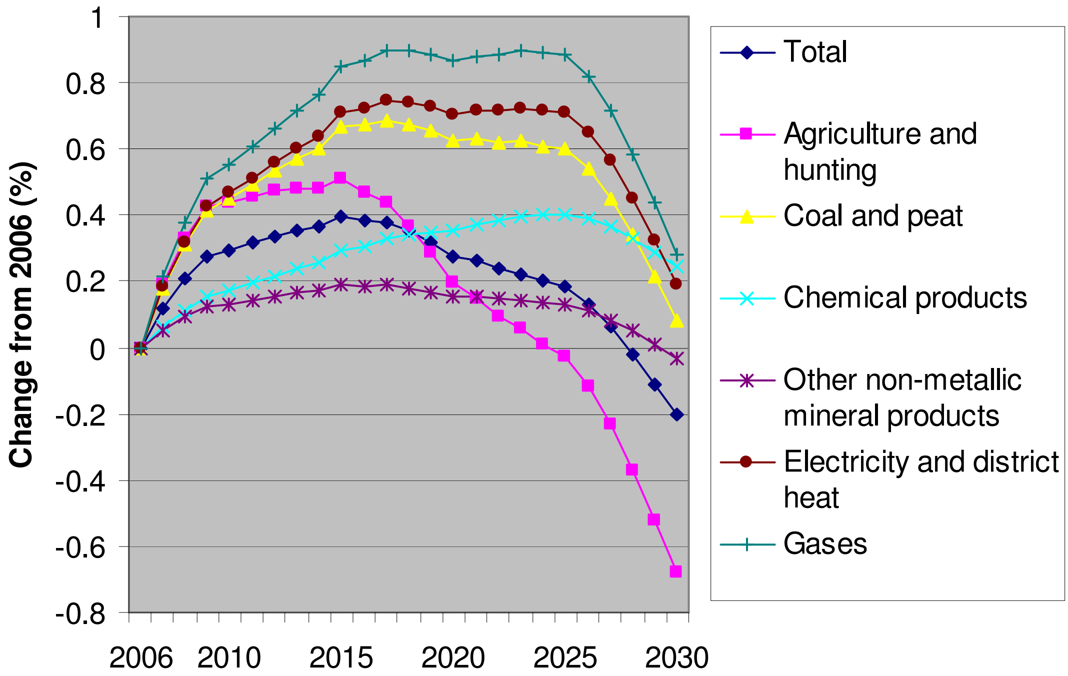


Source: author's calculations

Figure 7: Output of most important energy-using sectors

As Table 1 shows, more than 60 percent of the energy use in Germany derives from four production sectors: *refined petroleum products and other fuels* (CPA 23), *chemical products* (CPA 24), *basic metals* (CPA 27) and *electricity and district heat* (CPA 40.1 and 40.3). Thus, the development of these sectors is crucial for the development of aggregate energy use in Germany. Therefore, Figure 7 shows the impact of demographic change on the output of these sectors.

Figure 7 reveals that demographic change reduces the output of *refined petroleum products and other fuels* by 0.8 percent, which is consistent with the reduction in consumption expenditure on fuels and lubricants (Figure 6). The impact on the output of *electricity and district heat* is positive, which fits with the observed increase in consumption expenditure on these products shown in Figure 6 as well. The production of *chemical products* rises by 0.4 percent, which could be explained by the fact that this sector contains – among others – pharmaceutical products, which are increasingly consumed in an ageing society. The impact of demographic change on *basic metals* is very small, which is reasonable because basic metals are almost exclusively used as intermediate inputs in other industries, so a change in the structure of private households' consumption expenditures is not likely to affect this sector very much.



Source: author's calculations

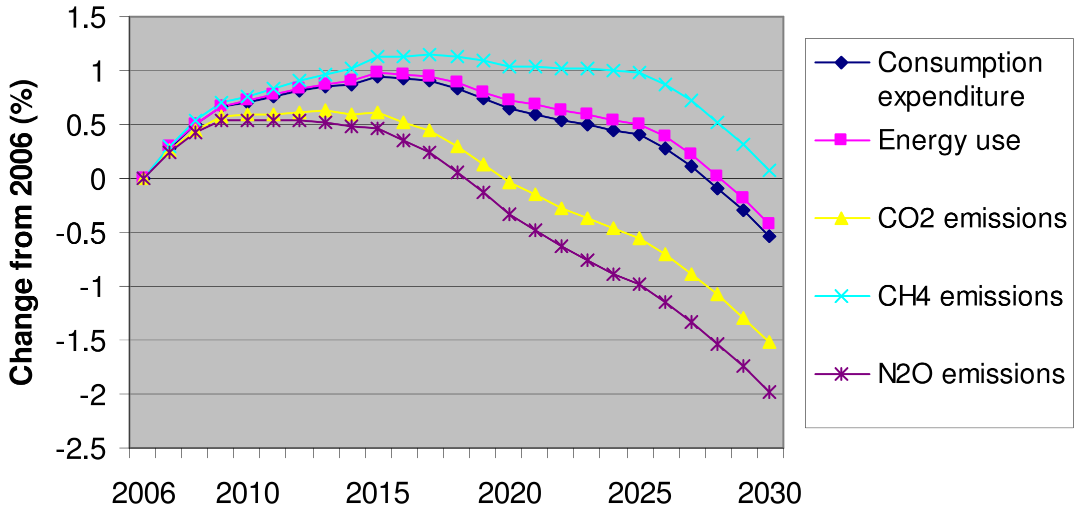
Figure 8: Output of most important emission-generating sectors

Like energy use, greenhouse gas emissions can also be traced back mostly to a small number of production sectors, as shown in Table 3. The impact of demographic change on the production level of these sectors is shown in Figure 8. The sector *agriculture and hunting* is of particular interest, because it is responsible for more than 90 percent of Germany's CH4 and N2O emissions. According to Figure 8, the impact of demographic change on that sector's production is initially positive. The output of *agriculture and hunting* rises by about 0.5 percent until the year 2015, then it declines slowly, returning to its initial value by 2025. At the end of the simulation period, the output of *agriculture and hunting* is reduced by almost 0.7 percent compared to 2006. This suggests that the emissions of CH4 and N2O, which are mainly caused by this sector, will also be reduced after an initial increase.

Unfortunately, the development of the other emission-generating sectors differs from that of *agriculture and hunting*. The output of the sector electricity and district heat, which is responsible for more than 40 percent of Germany's CO2 emissions, is positively affected by demographic change. It rises by roughly 0.7 percent from 2006 to 2015, then remains at that level for a decade, and finally starts to decline rapidly from 2025 onward. In 2030, the output of *electricity and district heat* is still 0.2 percent higher than in 2006. Thus, by increasing the output of the most important CO2-emitting sector, demographic change is likely to raise overall CO2 emissions.

In the other emission-generating sectors, demographic change generally has a positive impact on output as well. The production of *gases* rises by 0.9 percent for some time, while that of *coal and peat* rises by between 0.6 and 0.7 percent. The impact of demographic change on *other non-metallic mineral products* is relatively small, because this sector's output is mostly used as an intermediate input.

So far, the discussion has centred on the consumption of individual products and the production of individual sectors. What matters at the end of the day, however, is the impact of demographic change on aggregate energy use and emissions. Therefore, the following figures show this impact, first on households, then on firms, and then in total.



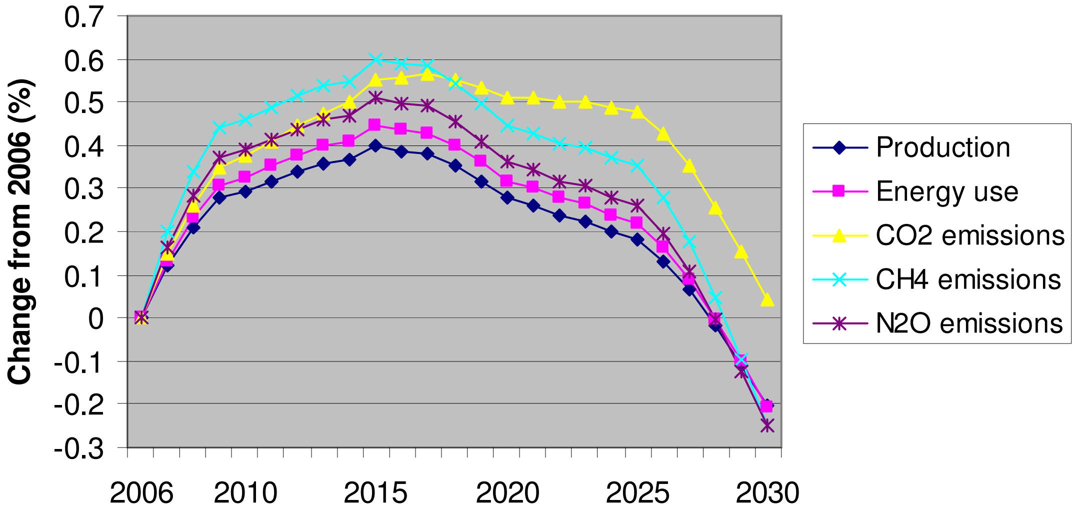
Source: author's calculations

Figure 9: Energy use and emissions by households

Figure 9 shows the impact of demographic change on energy use and emissions by private households. In order to put things into the proper perspective, total consumption expenditure is also shown. One can see from the figure that the energy use of households closely follows the development of total consumption expenditure. Thus, the energy intensity of consumption remains more or less unaffected.

Interestingly, the greenhouse gas emissions by households are affected by demographic change in different ways. CH4 emissions increase by more than one percent for quite some time. At the end of the simulation period they have returned to their 2006 value, while total consumption expenditure has fallen by 0.5 percent. This means that the CH4 intensity of consumption has been increased. The other two types of emissions, by contrast, are reduced, by two percent in the case of N20 and 1.5 percent in the case of CO2. Thus, demographic change reduces the N2O and CO2 intensities of consumption.

In order to understand the different developments of CO2, CH4 and N2O emissions, it is useful to take another look at Table 4. That table shows that households generate CO2 and N2O emissions mainly by consuming refined petroleum products, i. e. gasoline. They generate CH4 emissions mainly by consuming products of forestry, logging etc. (i. e. firewood) and natural gas. More loosely speaking, households generate CO2 and N2O emissions by driving cars and CH4 emissions by heating their homes. As demographic change takes place, the ageing population uses cars less frequently and consumes more energy for heating purposes. This tends to increase CH4 emissions and to reduce CO2 and N2O emissions.

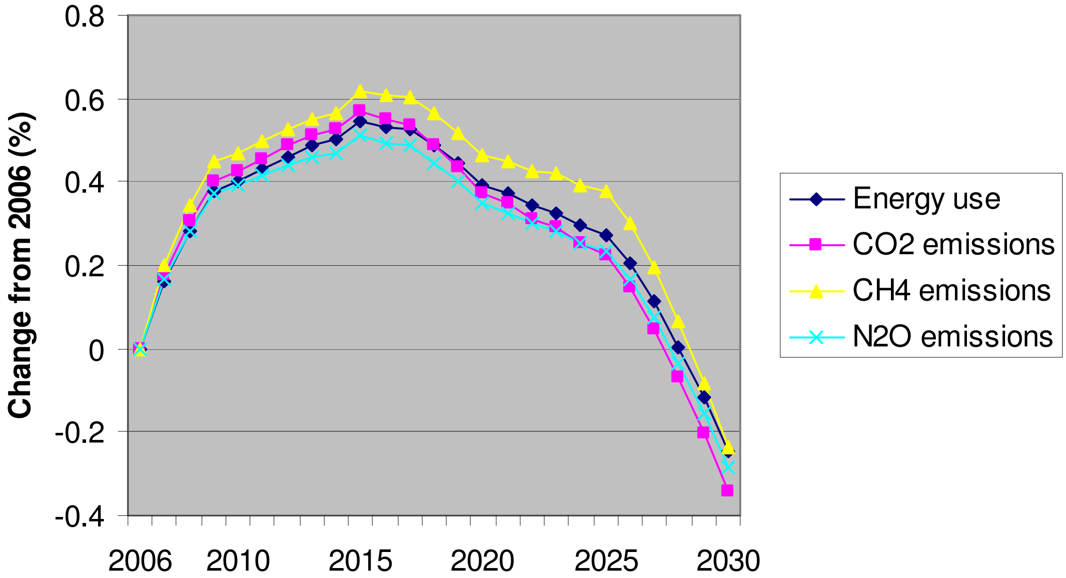


Source: author's calculations

Figure 10: Energy use and emissions by production sectors

Figure 10 is similar to Figure 9, but it refers to production sectors instead of private households. Therefore, the development of total production is shown rather than total consumption expenditure. Interestingly, during the first couple of years, emissions rise more quickly than total production, which means that the emission intensity of production is increased. CH4 emissions experience the largest increase, rising by 0.6 percent, while total production rises by only 0.4 percent. After the year 2015, energy use and greenhouse gas emissions start to fall along with total production. At the end of the simulation period, total production has fallen by 0.25 percent, while energy use has fallen by 0.2 percent, which means that energy intensity of production has been reduced minimally. CH4 emissions and N2O emissions have fallen by the same percentage as total production, so the CH4 and N2O intensities have returned to their initial value. CO2 emissions, however, are still slightly higher than in 2006, so the CO2 intensity of production is also higher than in 2006.

These findings are consistent with the sectoral production projection shown in Figure 8. As Table 3 has shown, the sector *agriculture and hunting* is the main source of CH4 and N2O emissions. Since that sector's output is reduced by 0.7 percent in 2030, it is not surprising that CH4 emissions and N2O emissions as a whole are reduced. CO2 emissions, by contrast, mostly originate from the sector *electricity and district heat*. Since this sector's output in 2030 is still 0.2 percent higher than in 2006, it is plausible that CO2 emissions are also higher than in 2006.



Source: author's calculations

Figure 11: Aggregate energy use and emissions

Finally, Figure 11 shows the development of aggregate energy use and emissions by both private households and production sectors. Interestingly, the variations which can be observed between different kinds of emissions in Figure 9 and Figure 10 are considerably less pronounces in Figure 11. For example, according to Figure 9 the CH4 emissions of private households in 2030 are still (slightly) higher than in 2006, whereas the other types of emission have been reduced by 1.5 and two percent, respectively. Figure 11, by contrast, shows that aggregate emissions of all types are reduced by between 0.2 and 0.4 percent.

The reason for this could be that in some ways the emissions of production sectors kind of substitute for the emissions of private households. For example, as Figure 6 shows, demographic change reduces the consumption of fuels and lubricants for motor vehicles. At the same time, it raises the consumption of heat energy and electricity. As the projection of consumption expenditures is converted from consumption purposes into commodity groups, these developments are reflected as a decrease in the consumption of *refined petroleum products and other fuels* and an increase in the consumption of *electricity and district heat*. According to Table 4, the consumption of *refined petroleum products and other fuels* is responsible for most of the CO2 and N20 emissions of private households, whereas the consumption *electricity and district heat* does not generate any (direct!) emissions. Therefore, our calculations show a reduction in the CO2 and N2O emissions of private households. However, even though the consumption of *electricity and district heat* does not generate any emissions, their production surely does, as evidenced by Table 3. This explains why CO2 emissions of production sectors rise. The net effect is that CO2 emissions fall by a very small percentage.

These observations show the importance of taking both direct and indirect effects into account. Our calculations suggest that demographic change tends to reduce the direct CO_2 emissions of private households, but one must keep in mind that the indirect effects, which arise due to the backward linkages between industries, may offset this reduction in direct CO_2 emissions to a certain extent. The same phenomenon can also occur in the opposite direction, as in the case of CH_4 according to our calculations.

VI Conclusion

The aim of this paper was to examine the impact of demographic change on energy use and emissions. For reasons of data availability and familiarity, Germany was chosen as a case study. The methodology consisted of constructing a demand projection based on household projections and household survey data and feeding that consumption projection into an environmental input-output (EIO) model as a demand impulse.

The findings from this study show that demographic change has a significant impact on the structure of private households' consumption expenditure. The most important impacts are observed in the areas of health and education. The energy use of households is also significantly affected. Although the total energy consumption of households moves closely in line with total consumption expenditure, which means that the energy intensity of consumption is barely affected, the consumption of different types of energy displays stronger reactions. Generally, the findings from this paper show that demographic change tends to increase the consumption of energy for heating purposes and to reduce the consumption of motor vehicle fuels. Thus, demographic change has an interesting effect on the 'energy mix' consumed by private households. The change in the structure of consumption expenditures also triggers effects on the sectoral production of output. Most notably, the output of the sector *refined petroleum products and other fuels* is reduced, while the output of the sector *electricity and district heat* is increased.

As demographic change leads to a redistribution of consumption expenditure between different energy sources, it also affects the emissions of private households. It raises the CH_4 intensity of consumption while lowering the CO_2 and N_2O intensities of consumption. The emission intensities of production are generally increased, but in the cases of N_2O and CH_4 they return to their initial values by the year 2030. The CO_2 intensity of production is generally increased.

Concerning aggregate emissions, the impact of demographic change is surprisingly small. The reason for this is that changes in the emission intensities of households and production sectors tend to cancel each other. For example, as CO_2 emissions of households fall by 1.5 percent, the same emissions of production sectors rise (slightly), and the net result is a reduction of roughly 0.35 percent.

However, it must be kept in mind that the findings presented in this paper have been derived under a set of restrictive assumptions. Most notably, the consumption patterns of each age group from 2003 were kept constant for a projection of consumption expenditures up to the year 2030. In reality, one may expect that consumption patterns change over such a long time period, for example due to growing incomes, changing prices, or cohort effects. Furthermore, the input-output analysis was based on technical coefficients from the 2004 input-output table. In reality, these coefficients may be affected by technological change or substitution effects. Future research should attempt to incorporate these effects in a more general model with endogenous coefficients of consumption and production.

Appendix

Code	Description
110000	Food
120000	Non-alcoholic beverages
210000	Alcoholic beverages
220000	Tobacco
230000	Narcotics
311000	Clothing materials
312900	Hosiery for men, women and children
312901	Garments for men (excl. hosiery)
312902	Garments for women (excl. hosiery)
312903	Garments for children of 0 to 13 years (excl. hosiery)
313000	Other articles of clothing and clothing accessories
314100	Darning, mending, repair and altering of garments, hire of garments
314200	Dry-cleaning, laundering and dyeing of garments
321100	Shoes for men
321200	Shoes for women
321300	Shoes for children of 0 to 13 years
321900	Shoe accessories
322000	Repair and hire of footwear
411040	Actual rentals of long-term tenants in hotels, guesthouses, etc.
411050	Sublease for main or secondary residences
411900	Actual rentals for main residence (including service and utility bills, excluding heating cost and rentals for garages)
412900	Actual rentals for secondary residences (including service and utility bills, excluding heat-ing cost and rentals for garages)
421031	Imputed rentals of owners occupying their main residence, building constructed before 1949 (excluding service and utility bills and rentals for garages)
421032	Imputed rentals of owners occupying their main residence, building constructed between 1949 and 1990 (excluding service and utility bills and rentals for garages)
421033	Imputed rentals of owners occupying their main residence, building constructed after 1990 (excluding service and utility bills and rentals for garages)
422040	Imputed rentals of households paying a reduced rental or housed free
422050	Imputed rentals for secondary residences (excluding service and utility bills and rentals for garages)
431001	Materials for the maintenance and repair of the dwelling (tenant)
431002	Materials for the maintenance and repair of the dwelling (owner-occupier)
432010	Services for the maintenance and repair of the dwelling (owner-occupier)
432900	Services for the maintenance and repair of the dwelling (tenant)
445900	Service and utility bills without heating cost for owner-occupied main residence
445901	Service and utility bills for owner-occupied real estate not permanently used
451010	Electricity (including solar energy)
452000	Gas
453000	Liquid fuels
454000	Solid fuels
455000	Heat energy
456000	Ice used for cooling and refrigeration purposes.
511900	Furniture and furnishings
512900	Carpets and other floor coverings
513900	Delivery, installation and repair of furniture, furnishings and floor coverings
520900	Household textiles
520901	Repair of household textiles
531100	Refrigerators, freezers and fridge-freezers
531200	Washing machines, dryers, drying cabinets, dishwashers, ironing and pressing machines

Code	Description
531901	Other major household appliances Sonstige größere Haushaltsgeräte
532000	Small electric household appliances
533900	Repair of household appliances and delivery and installation of major household appliances
540900	Glassware, tableware and household utensils
540901	Repair of Glassware, tableware and household utensils
551900	Tools and equipment for house and garden
552900	Miscellaneous accessories for house and garden
561000	Non-durable household goods
562000	Domestic services and household services
611010	Pharmaceutical products: only co-payment and deductibles
611900	Pharmaceutical products: without co-payment and deductibles
612010	Other medical products: only co-payment and deductibles
612900	Other medical products: without co-payment and deductibles
613050	Orthopaedic footwear (incl. co-payment)
613072	Dentures (incl. co-payments)
613090	Repair of Therapeutic appliances and equipment (incl. co-payments)
613900	Therapeutic appliances and equipment (incl. rentals and co-payments)
621000	Medical services (incl. co-payments)
622000	Dental services (incl. co-payments)
623900	Paramedical services (incl. co-payments)
630000	Hospital services (incl. co-payments)
711100	Purchase of new motor cars
711200	Purchase of used motor cars
712000	Purchase of motor cycles
713000	Purchase of bicycles
714000	Purchase of animal-drawn vehicles
721070	Spare parts and accessories for bicycles
721900	Spare parts and accessories for motor vehicles and motor cycles
722000	Fuels and lubricants for personal transport equipment
723000	Maintenance and repair of personal transport equipment
724060	Actual rentals for garages or parking spaces
724061	Imputed rentals for owner-occupied garages or parking spaces
724062	Imputed rentals for garages or parking spaces provided for free (main residence)
724900	Other services in respect of personal transport equipment
730901	Passenger transport not by air (without overnight stay)
730902	Passenger transport not by air (with overnight stay)
733100	Passenger transport by air (without overnight stay)
733200	Passenger transport by air (with overnight stay)
810000	Postal services
820000	Telephone and telefax equipment
830020	Telecommunication services - mobile telephony
830031	Telecommunication services - internet connection services
830900	Telecommunication services - telephone, telefax, telegram
911100	Equipment for the reception, recording and reproduction of sound
911200	Equipment for the reception, recording and reproduction of sound & pictures (excl. cameras)
912000	Photographic and cinematographic equipment and optical instruments
913000	Information processing equipment and software
914000	Recording media
915000	Repair of audio-visual, photographic and information processing equipment
921900	Other major durables for culture, sport, camping and recreation
923900	Maintenance and repair of other major durables for culture, sport, camping and recreation
931900	Games, toys and hobbies
932010	Equipment for sport, camping and open-air recreation
933900	Garden products and nondurable goods for garden maintenance

Code	Description
933901	Plants and flowers
934900	Pets and related products incl. veterinary services
941020	Extracurricular education in sport or fine arts
941900	Events or establishments of sport and culture
942400	Other recreational and cultural services
942900	Radio and television license fee
942901	Hire of equipment and accessories for culture
943000	Games of chance
951000	Books
952900	Newspapers and periodicals
953900	Miscellaneous printed matter
954900	Stationery and drawing materials
961000	Package holidays (inland)
962000	Package holidays (abroad)
1010900	Child care
1020900	Study and exam fees at schools and universities
1050010	Private lessons
1050900	Fees for educational programmes etc.
1111000	Restaurants, cafés and the like
1112000	Canteens
1120000	Accommodation services
1211010	Services of hairdressing salons and barbers
1211030	Other personal grooming services
1212900	Durable goods for personal case (incl repairs)
1213900	Articles for personal hygiene and beauty products
1213901	Other nondurable goods for personal care
1220000	Prostitution
1231000	Jewellery, clocks and watches (incl repairs)
1232000	Other personaleffects
1240900	Care services for old, disabled and other persons in need of care
1250900	Insurance and financial services n.e.c.
1262070	Leasing of motor vehicles and motor cycles
1270900	Other services n.e.c.

Source: Statistisches Bundesamt, authors' translation

Table A1: Classification of consumption expenditure by purpose

CPA code	Short name
1	Agriculture
2	Forestry
5	Fish
10	Coal
11	Crude oil and natural gas
12	Uranium
13	Metal ores
14	Other mining and quarrying products
15.1 - 15.8	Food products
15.9	Beverages
16	Tobacco products
17	Textiles
18	Clothing
19	Lether and leather products
20	Products of wood, cork and straw
21.1	Ppulp, paper and paperboard
21.2	Articles of paper and paperboard
22.1	Printed media
22.2 - 22.3	Printing services and recorded media
23	Refined petroleum products and other fuels
24.4	Pharmaceutical products
24 (without 24.4)	Chemical products
25.1	Rubber products
25.2	Plastic products
26.1	Glass and glass products
26.2 - 26.8	Ceramics and other non-metallic mineral products
27.1. - 27.3	Basic ferrous metals
27.4	Basic precious metals and other non-ferrous metals
27.5	Foundry work services
28	Fabricated metal products
29	Machinery
30	Office machinery and computers
31	Electrical machinery
32	Radio, television and communcation equipment
33	Medical, precision and optical instruments; watches and clocks
34	Motor vehicles
35	Other transport equipment
36	Furniture, other manufactured goods n.e.c.
37	Secondary raw materials
40.1, 40.3	Electricity, steam and hot water
40.2	Gases
41	Water
45.1 - 45.2	General construction work
45.3 - 45.5	Specific construction work
50	Trade, maintenance and repair of motor vehicles
51	Wholesale trade
52	Retail trade and repairs
55	Hotel and restaurant services
60.1	Railway transportation services
60.2 - 60.3	Other land transportation services
61	Water transport services
62	Air transport services

CPA code	Short name
63	Supporting transport services
64	Post and telecommuncation
65	Financial intermediation
66	Insurance and pension funding
67	Services auxiliary to financial intermediation
70	Real estate services
71	Renting services
72	Computer and related services
73	R&D services
74	Other business services
75.1 - 75.2	Public administration and defence
75.3	Compulsory social security services
80	Education
85	Health and social work
90	Sewage and waste disposal
91	Membership organisation services n.e.c.
92	Recreation, culture, sports
93	Other services
95	Household services

Source: Statistik Austria (modified)

Table A2: Sector classification for input-output calculations

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