Conference paper SCORAI 2013

Explaining the variation in greenhouse gas emissions between households: Physical circumstances or pro-environmental motivation?

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Abstract

Consumption-accounted greenhouse gas (GHG) emissions vary considerably between households. Research originating from different traditions; consumption research, urban planning and environmental psychology, have explored different types of explanatory variables and provided different insights into this matter. This study explores the explanatory value of variables from different fields of research in the same empirical material, including socio-economic variables (income, household size, sex, age), motivational variables (pro-environmental attitudes and social norms) and physical variables (the type of dwelling and the distances to work and public/commercial services). The latter involve the use of geographical data sources. A survey was distributed to 2500 Swedish households with a response rate of 40%. GHG emissions were estimated for transport, residential energy, food and other consumption, using several data-sources from the survey questionnaire and registers such as the odometer readings of cars and electricity consumption from utility providers. The results point toward the importance of explanatory variables that have to do with circumstances rather than motivations for pro-environmental behaviours. Net income was found to be the most important variable to explain GHG emissions, followed by physical parameters dwelling type and an index of distances to work and public/commercial services.

Keywords: Greenhouse gas emissions; Consumption; Households; Energy; Transport; Food.

1. Introduction

Emissions scenarios with at least a likely[1] chance of keeping global warming below the long-term EU target of 2 degrees, typically require reductions of global greenhouse gas (GHG) emissions from a current global average of over 6 tons of carbon dioxide equivalents per capita and year to around 2 tons already by 2050 (Rogelj et al, 2011). Consumption-accounted GHG emissions vary considerably both between nations and between individuals and households (e.g. Davis & Caldeira, 2010; Kerkhof et al, 2009). In this paper we will quantify and explain the variance in GHG emissions in a sample of Swedish households.

Different theoretical and methodological approaches have explored different types of explanatory variables, and how they affect households' GHG emissions. Studies of consumption patterns using nation-wide household budget surveys have established that the most important explanatory variable is the total income/expenditures of the households. Expenditure elasticities of total energy use and emissions have estimated to as high as 0.57 in the US, 0.64 in Japan, 0.78 in Australia, 0.86 in Denmark and India, 0.91 in Spain and 1.00 in Brazil (Lenzen et al, 2006; Roca & Serrano, 2007; Shammin et al, 2010). This means that an increase in total consumption by 1% can be expected to cause an increase in emission by 0.5-1%. An important strength of these studies is their completeness with respect to the description of all types of consumption, since low emissions following small expenditures in one consumption domain may rebound through larger expenditures and higher emissions in other domains (Alfredsson, 2004; Nässén & Holmberg, 2009). However, these surveys have been limited to the relatively narrow set of socio-economic variables, and other explanatory variables have not been controlled for.

Research focusing on urban planning has for apparent reasons emphasized the role of infrastructural and spatial parameters such as the density of cities and the distance to public and commercial services (shopping centres, public travel, schools etc.) that may lock people into for example automobile dependency (Newman & Kenworthy, 1999; Næss, 1996, 2006). In a comparison of Swedish municipalities, Næss (1996) found that urban form parameters had an even larger impact on energy use for transport than socio-economic parameters such as income.

In terms of theoretical development, environmental psychology is probably the research field related to this topic that has reached the furthest. The theory of planned behaviour (TPB, Ajzen 1991), which predicts behaviours from attitudes, norms, and perceived behavioural control, has been very influential in this research field. However, TPB and other psychological theories usually focus on specific pro-environmental behaviours such as recycling habits, energy conservation or the purchase of eco-labelled products. This makes it problematic to transfer them directly into the context of this paper, since applying the same methodology to all types of behaviours related to GHG emissions would be an enormous task. There may also be a considerable disconnect between the intentions to reduce environmental impact and the actual effect, particularly in the case of GHG emissions. Some intentionally pro-environmental behaviours such as recycling or turning off the lights may have real but small effects in relation to the total volume of consumption, whereas other behaviours merely serve as environmental symbols. Moreover, some behaviours may be associated with low emissions without being environmentally motivated. Individuals may for example bike to work because it is convenient, healthy or economical. See Peattie (2010) for a thorough review of these matters. Altogether, this means that measuring the impact of motivational factors on GHG emissions will need to rely on more broadly defined pro-environmental attitudes. We have also measured social norms connected to some particularly GHG intensive activities.

[1] 'Likely' defined as a probability of more than 66%.

In this interdisciplinary study, we attempt to explore the explanatory value of variables from these different fields of research in the same empirical material:

- Socio-economic variables: Income, Household size, Sex, Age
- Motivational variables: Pro-environmental Attitudes and Social norms
- Physical variables: Distances to work and public/commercial services, Type of dwelling

Section 2 presents the methodology used in the paper including a description of how GHG emissions were estimated and how the explanatory variables were defined. The main results of the study are presented in Section 3 and discussed in Section 4.

2. Methodology

Figure 1 provides a summarizing framework for the empirical analyses performed in this paper. The three types of explanatory variables to the left are all potentially important on their own for explaining GHG emissions. However, both the motivational and the physical variables may to some degree serve as mediator variables, for example if high income individuals adopt pro-environmental attitudes or move to detached houses in wealthy suburbs.

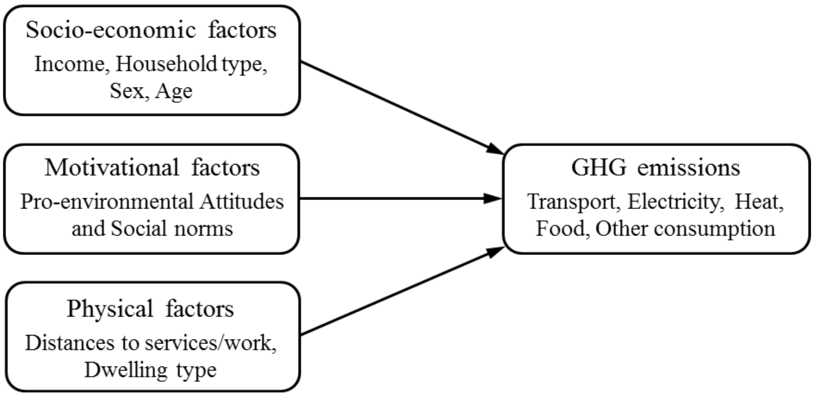


Figure 1. Summary of studied variables.

Section 2.1 describes the survey itself. Section 2.2 describes how the households' GHG emissions were estimated including residential energy use, car and public transport, aviation, food and other consumption. Section 2.3 describes the selected explanatory variables.

2.1 The survey

The postal survey was sent out in May 2012, to a random sample of 2500 individuals between 20 and 65 years of age, residing in the region of Västra Götaland in the southwest of Sweden. The net response rate amounted to 40.1%, after two mail send-outs, three postcard reminders and a telephone reminder. Although this is a relatively high response rate compared to international levels, the fact that less than half of the sample chose not to participate required a non-response rate analysis. We compared characteristics of the sample population to averages in the Västra Götaland region and found some important differences. Women were more likely to answer the survey (55% of the respondents), individuals with higher incomes were also overrepresented in the sample; the median income was 6% higher than for the total population. We also found an age bias as respondents are on average four years older than an average citizen (for the specified cohort). Finally, there is a fairly strong bias towards higher education in the survey sample as 60% of the respondents had post-secondary education, compared to 39% among the general population in the region.

2.2 Greenhouse gas emissions

GHG emissions were calculated as the sum of emissions from residential energy use (2.2.1), car and public transport (2.2.2), aviation (2.2.3), food (2.2.4) and other consumption (2.2.5). Emissions of the three most important gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are included and expressed as carbon dioxide equivalents (CO_2e) based on their respective global warming potential (GWP) over 100 years. In all analyses, the GHG emissions are presented per capita (adult).

2.2.1 Emissions from residential energy use

For electricity consumption, the preferred source of energy data was the annual consumption measured by the utility provider. In the questionnaire, respondents could give their authorization to allow that data on their electricity consumption was collected from their respective utility provider. 30% chose to share this information but some could not be collected for other reasons providing electricity data from 215 respondents (22%). For the households where real data could not be gathered, electricity use was estimated using relevant explanatory data from the survey. To improve the fit of these estimates, different explanatory models were tested on the households with both measured data and questionnaire data. The best fit to the measured data was found for a model with the following predictors (R^2=0.61):

1. Number of persons in the household to the power of 0.7 (consumption increases less than proportional with the number of persons, due to e.g. collective use of appliances).
2. Floor area per person.
3. Dwelling type: multi-family or single-family house.
4. Type of white goods in the dwelling.
5. Self-assessed electricity use behaviour (use of energy efficient lighting/leave appliances on standby or not).

For *space and water heating* (also including electric heating), GHG emissions were calculated as the product of the five factors below. The preferred source of energy data was the Energy Declarations register. This register provides data on energy use and heating technologies for buildings, which allows calculations of CO_2e-emission. However, all buildings have not undergone energy declaration yet and only 375 dwellings with full data availability could be identified from the register (38% of the respondents). Data from the survey was used for the remaining households.

1. Floor area (m^2).
2. Energy performance ($kWh_{useful}/m^2/yr$): taken from the Energy Declaration where available or estimated from the year of construction using official statistics (Swedish Energy Agency, 2012).
3. Heating system efficiency ($kWh_{delivered}/kWh_{useful}$): estimated from heating technology specified in the Energy Declaration or stated in the survey (boiler, heat pump, resistance heating, district heating).
4. Indoor temperature: Based on the rule of thumb that each centigrade affects the demand for space heating by 5%.
5. Emission factor ($kgCO_2e/kWh_{delivered}$): Emission factors for fuels taken from a compilation by the Swedish Environmental Protection Agency. Emission factors for electricity calculated as the average EU mix (0.305 $kgCO_2e/kWh$) and for district heating the average for Sweden (0.101 $kgCO_2e/kWh$).

2.2.2 Emissions from private cars and public transport

In order to measure emissions from car transport, information on yearly mileage for each household participating in the study was collected from the Swedish Road Registry (SRR). SRR stores odometer indications from the two most recent vehicle inspections together with other relevant data such as fuel type, fuel consumption, CO_2-emissions and car model. A limitation to the SRR data is that no odometer readings are done on cars less than three years old. For these cars we had to rely on the self-stated estimates on yearly distance taken from the questionnaire, together with the fuel consumption of the car (from SRR) to estimate the CO_2 emissions. Also, for the households that had indicated that they had access to a company car or took part in a car pool; the self-stated distance was used since company cars are not registered with the household/respondent in the SRR.

The fuel consumption stated in the SRR is based on test-cycle scores where all electric equipment is turned off and where driving conditions are optimal, while CO_2 emissions from real traffic indicate 15-40% higher fuel consumption (Patterson et al., 2011). In our estimates we used a conservative addition by 20%.

CO_2-emissions stemming from the use of public transportation were estimated using information on travel behaviours from the survey together with estimates of emissions intensities from public transport provided by the local public transport provider, amounting to 0.03 kgCO_2.

2.2.3 Emissions from aviation

GHG emissions from aviation were estimated using the questionnaire with questions about the number of non-work related flights they had conducted to Nordic- and European destinations during the last 2 years and international flights during the last 5 years. “Average distances” for the Nordic, European and international trips were then calculated using data on the number of flights to different destinations from the main international airport in the region. In order to translate distances into CO_2 emissions, estimates of average aircraft emissions per passenger kilometres from the Finish LIPASTO-calculation system for air traffic was used. Emissions at high altitudes generate additional GWP effects because of contrails and induced cloud formation. A factor to 1.7 has been used based on an estimate provided by Azar & Johansson (2012).

2.2.4 Emissions from food

The average GHG-emissions from Swedish food consumption have been estimated to 1500 kg CO_2e per capita of which 800 kg originates from meat and 700 kg from all other food products (Bryngelsson et al., 2013). Since measuring all types of food consumption would have been impossible with our survey approach, we focused on the meat consumption which accounts for most of the variation between individuals. The GHG-emissions from meat were based on a multi-item question where respondents were asked to assess how many times during last week they had eaten dishes with beef, poultry, pork, game, fish or all-vegetarian. Using GHG emission data from a meta-study (Röös, 2012), the individuals’ GHG-emissions from meat were calculated and calibrated to a sample average of 800 kg CO_2e per capita. Emissions from other food types where assumed to be 700 kg CO_2e per capita for all individuals in the sample.

2.2.5 Emissions from other consumption

In addition to the main categories of GHG intensive consumption, a significant portion of a household’s emissions is caused by “other consumption”, i.e. a multitude of products and services that households’ purchase. These items typically have low GHG intensities (kgCO_2e/SEK), but the aggregated consumption volume is large and should not be neglected. It has previously been shown that households with low emissions from direct energy use (transport and residential energy) may have larger emissions from other types of consumption through so-called rebound effects (Alfredsson, 2004; Nässén & Holmberg, 2009). Ideally each household’s consumption should be measured in detail in order to pick up any differences between households consumption patterns, but since this option would require an investigation at the scale of the national household budget surveys we settled for an approximate approach.

A relationship between expenditures and GHG emissions from "other consumption" was established using data from the Swedish household budget survey of around 2000 households, combined with GHG intensities for 99 categories of products and service taken from the Environmental Accounts database. This resulted in an elasticity of GHG emissions with respect to expenditures on other consumption of 1.07 as shown by Figure 2.

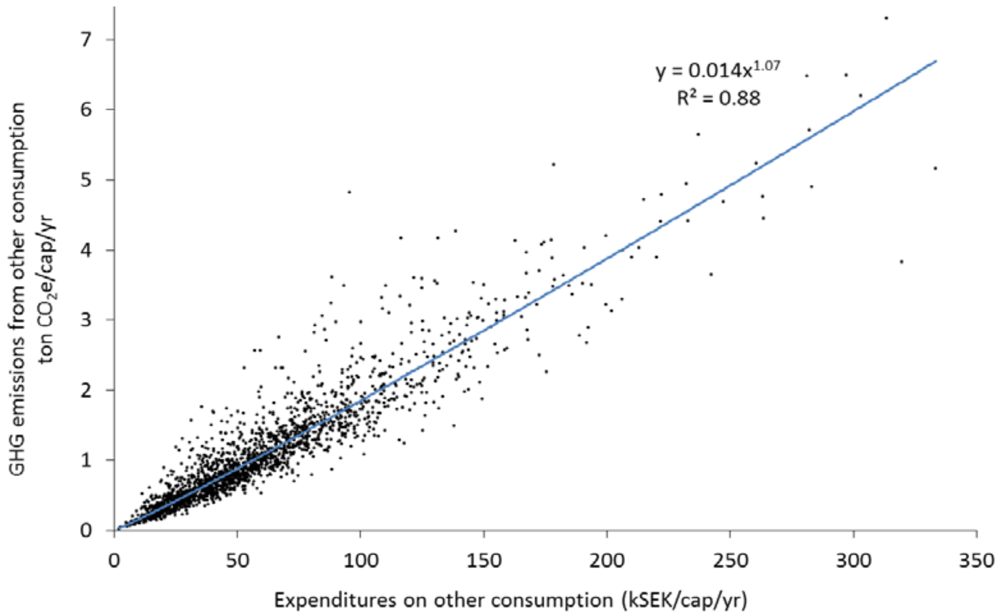


Figure 2. The relationship between expenditures and GHG emissions from "other consumption", i.e. the sum of non-GHG-intensive products and services. Each dot represents a household. The data is based on consumption data from the Swedish household budget survey combined with GHG intensities.

This simple model shows that expenditure alone is a very strong predictor of GHG emissions from other consumption (R^2=0.88), which is due to the relatively small differences in kgCO_2e/SEK between different types of products. A household's emission from other consumption is primarily explained by the amount of expenditures and not by the composition of the consumption basket (clothes, electronics, books, furniture, etc.). The survey was constructed to utilize this short-cut and the households' total annual expenditures on other consumption was calculated as the gross income of the household minus taxes, annual household savings, rent, and expenditures in the GHG intensive consumption categories (Section 2.2.1-2.2.4). Then GHG emissions from other consumption could be approximated using the relationship shown in Figure 2.

2.3 Explanatory variables

The study incorporates three types of explanatory variables as shown in Figure 1 and described in the following sub-sections.

2.3.1 Socio-economic variables

Income has previously been shown to be the number one variable for explaining GHG emissions. *Net income* was calculated from the self-stated salaries of all adults in the household, deducting the taxes according to each adult's income dependent tax rate, and adding child benefits for households with children.

While both emissions and net incomes are express per capita (adult) we also include the *number of adults* and the *number of children* in the analyses since household size may still affect consumption. Because of collective goods, i.e. goods that several individuals can use without affecting the other's usage, and economies of scale (e.g. larger and cheaper food packages), a large household can afford other types of consumption than small households with the same income per capita. Households with only one adult are also much likely to own a car than households with two adults.

Age was also included, since this variable may have implications in all domains of consumption. *Sex* was also included, since previous research has shown that men travel by car to a larger degree than women and also eat more meat (Räty & Carlsson-Kanyama, 2010). This variable was coded 0 for woman and 1 for man.

2.3.2 Motivational variables

Pro-environmental attitudes were measured as the combination of self-stated interest in environmental issues and the concern for the future impacts of climate change (Cronbach's alpha 0.74).

We also attempt to measure *pro-environmental social norms* (PESNs) for some behaviours that are central to GHG emissions; commuting, long-distance travel, vacations, residential energy use and food as shown in Table 1. The questions are formulated as statements which the respondent can agree or disagree with (scale 1-7). These statements can also be divided in two different types which may also capture different types of normative influence. The first type (statement 1-3) handle what significant others do, assuming that this in itself may have an influence on one's behaviour. The second type (statement 4-5) is about what is believed to be expected or considered desirable among significant others. Cialdini et al (1990) refer to these two types as *descriptive* and *injunctive* norms.

Table 1. Five questions on pro-environmental social norms (PESNs). For questions marked rev., the scale of the variable has been reversed so that a higher value indicates and expected pro-environmental influence.

	PESN	Valued statement: 'don't agree at all' to 'agree completely'	
1	Car	Most of my close friends take the car to work	(rev.)
2	Vegetarian	None of my close friends are vegetarians	(rev.)
3	Aviation	Most of my acquaintances avoid domestic flights when possible	
4	Vacation	Vacations at remote destinations give status among friends	(rev.)
5	Energy	My acquaintances expect me not to waste energy	

These five norm questions have a low internal consistency (Cronbach's α of 0.30) and also low pair-wise correlations. Hence a combined variable was not constructed.

2.3.3 Physical variables

To explore the role of the proximity to different functions, we establish a *Distance index*, calculated as a function of the road distances d_j from home to the closest coordinate of 10 different types of functions j (work, supermarket, city centre etc.), based in geographical data. The Distance index for each household i, is expressed as follows:

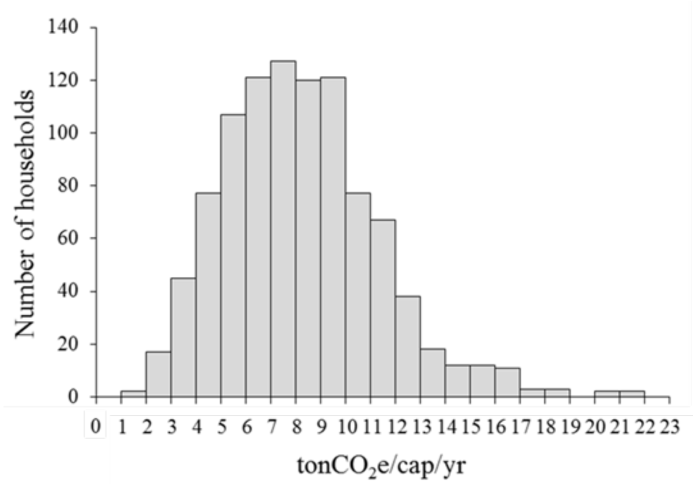
$$Distance\ index_i = \sum_{j=1}^{10} \propto_j \frac{d_{i,j}}{\bar{d}_j}$$

Where α_j is the weight of each distance type ($\sum\alpha_j$=1). Since the Swedish national travel survey 2011[2] showed that commuting constitutes 32% of the total travel distance by car, α_1 is set to 0.32. There is no detailed data available on the exact travel volumes to other functions and hence the other distance types have been given equal weight.

In addition the distance index we also include the binary variable *Dwelling type*, where 0 denotes an apartment in a multi-dwelling building and 1 denotes a detached or semi-detached dwelling.

3. Results

Figure 3 shows the results of the GHG emission estimates. The distribution is close to a normal distribution but with a longer tail for higher emissions. The mean emissions are found to be 8.2 tons of CO_2e per adult, with a standard deviation of 3.2 tons. While this estimate is relatively close to previous estimates of Swedish consumption accounted GHG emissions (SEPA, 2008), this result should not be seen as representative for the region. The result for aviation emissions of 1.4 tons of CO_2e per adult is for example unexpectedly high, which may at least partly be due to the somewhat higher level of income and significantly higher level of education in our sample.



	tonCO2e/cap/yr	
	M	S.D.
Total	8.2	3.2
Residential energy	2.2	1.7
Car/public travel	1.8	1.5
Aviation	1.4	1.4
Food	1.5	0.2
Other consumtion	1.3	1.0

Figure 3. To the left, a histogram of the total estimated GHG emissions for the 983 households in the sample. To the right, the means and standard deviations of emissions from different categories.

The correlations between the variables are shown in Table 2. All of the significant correlations had the expected sign. As expected all domains of GHG emissions were positively correlated with net income. Pro-environmental attitudes were negatively correlated with total emissions, and emissions from residential energy, car/public travel and food, but not significant for aviation and other consumption. Both of the physical parameters, distance index and dwelling type, were positively correlated with total emissions, emissions from residential energy and emissions from car/public travel. They were also positively correlated with each other and with net income.

[2] www.trafa.se

Table 2. Correlation matrix (Pearson's r) for emission categories and explanatory variables. Omitted numbers are not significant at the 5% level.

	GHG residential	GHG car/public travel	GHG aviation	GHG food	GHG other consumpt.	Net income	Pro-env. attitudes	Distance Index	Dwelling type
GHG total	.67***	.66***	.45***	.17***	.42***	.61***	-.07*	.21***	.37***
GHG residential	1	.27***			.08*	.26***	-.08*	.10**	.44***
GHG car/public travel		1		.11***	.15***	.39***	-.08**	.30***	.28***
GHG aviation			1	.06*		.14***			
GHG food				1		.09**	-.18***		
GHG other cons.					1	.73***			.09**
Net income						1		.12***	.15***
Pro-env. Attitudes							1		
Distance index								1	.14***
Dwelling type (detached house=1)									1

Significance levels: * = p < 0.05; ** = p < 0.01; *** = p < 0.001 (two-tailed test).

Table 3 shows the results from the regression analysis with total GHG emissions as the dependent variable, adding explanatory variables in a hierarchical procedure. Model 1 contains only socio-economic variables. Again, net income is the most important variable. In this model, the number of adults and children as well as age were also positive and significant, however not taking from the explanatory value of income, which standardized regression coefficient is almost identical to the bivariate correlation coefficient shown in Table 2.

Table 3. Results of OLS regressions. The presented values are standardized regression coefficients (Beta).

	Model 1	Model 2	Model 3	Model 4
Net income	0.60***	0.60***	0.59***	0.56***
No. Of adults	0.07**	0.07**	0.07*	*n.s.*
No. Of children	0.12***	0.12***	0.12***	0.06*
Sex	*n.s.*	*n.s.*	*n.s.*	*n.s.*
Age	0.09***	0.09***	0.09***	*n.s.*
Pro-environmental attitudes		-0.07**	-0.07**	-0.06**
Distance index			0.15***	0.12***
Dwelling type (detached=1)				0.25***
Adj. R^2	0.39	0.40	0.43	0.49
N	970	964	901	898

Significance levels: * = p < 0.05; ** = p < 0.01; *** = p < 0.001 (two-tailed test).

In Model 2, pro-environmental attitudes were added. This gives a significant negative contribution, but increases the fit of the model only marginally. Comparing Model 1 and Model 2 we see that the other regression coefficients are unaffected (as was shown in Table 2, pro-environmental attitudes are not significantly correlated with income). In Model 3, the distance index is added to the regression. This variable is strongly significant, improves the fit of the model (R^2_{adj} from 0.40 to 0.43) while the other regression coefficients remains unaffected. Finally, in Model 4, the variable dwelling type is added which further improves the fit of the model (R^2_{adj} 0.49). In this model, age and the number of adults becomes insignificant, while the regressions coefficient for number of children was halved and the regression coefficient for income also decreased somewhat. This means that dwelling type appears to be a mediator of both household size, age, and to some extent also for income. This is not unexpected; large families with high incomes tend to move to detached houses.

From the results in Table 3, we can see that the GHG emissions of households can be explained reasonably well with a rather small set of variables; net income, pro-environmental attitudes, distance index and dwelling type explains about half of the variation in GHG emissions (with a small contribution also from the number of children, which is not that interesting in itself). In Table 4, we quantify the importance of these four variables in terms of ton CO_2e/cap/yr. The number for binary variable dwelling type is the unstandardized regression coefficient, as this gives the difference between an apartment and a detached house. For the other parameters, the difference between 'low' to 'high' were defined as the effect of a change from -1 to +1 standard deviations. For a normal distribution, around 68% of the sample is found within this range.

In this way the difference between a low and a high income household was calculated to be 3.6 ton CO_2e/cap/yr. The physical variables also account for as much as 2.5 ton CO_2e/cap/yr together. Hence, a high income household living in a detached house in remote suburb could be expected to cause around 5 ton CO_2e/cap/yr more than a low income household in a central apartment. In comparison to these differences, the difference between weak and strong pro-environmental attitudes is much smaller (less than one tenth).

Table 4. GHG effects from a change from 'low' to 'high' in each variable. For the first three variables this has been calculated as the effect of a change from -1 to +1 standard deviations (the unstandardized regression coefficient times 2 std.dev.). For dwelling type, which is a binary variable, the value is just the unstandardized regression coefficient.

	Standardized GHG effect tCO_2e/cap/yr	Relative to average emissions %
Net income	3.6	44
Pro-environmental attitudes	0.4	5
Distance index	0.8	9
Dwelling type	1.7	21

While not included in the regressions above, we also set out to explore the effect of what we called pro-environmental social norms (PESNs). Five types of norm questions were evaluated as described in Table 1. The correlations between these and the different domains of GHG emissions are presented in Table 5. All correlations have the expected negative sign. A bit surprisingly, all of them have a higher correlation with total GHG emissions than the variable pro-environmental attitudes (Table 2). We also see a general pattern that the norms have the strongest impact within the expected domain, e.g. between the PESN for car use and car/public travel emissions (-0.28) and between the PESN for vegetarian food and emissions from food (-0.20). Emissions from aviation also correlate only with the PESNs for avoiding flying and vacations at remote destinations. Finally, in Section 2.3.2 we stressed that the three PESNs to the left in the table are based on a descriptive type of statement, describing what significant other do, compared to the two statements to the right, which describe the normative pressure in a more direct way (injunctive). From the results, we see a clear pattern that the descriptive norm statements give a stronger result. This will be further discussed in Section 4.2.

Table 5. Correlations (Pearson's r) between emission categories and different pro-environmental social norms (PESNs). Omitted numbers are not significant at the 5% level.

	PESN car	PESN vegetarian	PESN aviation	PESN vacation	PESN energy
GHG total	-.23***	-.08*	-.17***	-.08*	
GHG residential	-.17***	-.06*	-.07*		
GHG car & public travel	-.28***	-.08**	-.10**		
GHG aviation			-.13***	-.15***	
GHG food	-.14***	-.20***	-.15***		-.12***
GHG other consumption			-.08**		

Significance levels: * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$ (two-tailed test).

4. Discussion

The aim of this paper was to analyse the variance in GHG emissions generated by households, by exploring the influence of different types of explanatory variables. In line with previous research (e.g. Lenzen et al, 2006), income was found to be the single most important variable. The mechanisms behind this relationship are well-established; high-income households spend more, which generates more emissions. To some extent, high income households spend relatively more on products and services with lower emissions intensities and they may also invest more in for example energy efficient technologies, but this effect is not strong enough to compensate for the effect of a larger consumption volume. We will not dwell further on this matter here, but instead focus the discussion on interpreting our results of the physical variables and the variables for pro-environmental social norms that have also been identified as important factors affecting GHG emissions.

4.1 Physical structures

According to the results presented in Table 4, the difference in GHG emissions between a household living in an apartment in the city centre and a household living in a detached house in a suburb is around 2.5 tCO_2e/cap/yr, everything else equal. This finding could be interpreted in at least two different ways, either as an effect of choices by individuals, or as an effect of physical structures that shape behaviours and habits. Both views are true in a sense, but we argue that it is more useful to view it as a structural effect. First of all, differences in energy use and emissions have been connected to differences in physical variables like urban form also when different cities are compared (Newman & Kenworthy, 1999; Næss, 1996). In such comparisons, there is no reason to expect the initial preferences to differ between the populations. If preferences would differ between cities, it would be more likely that this would be due to physical differences which in the long run may shape habits and also preferences. Secondly, going back the individual's decisions about where and how to live, these are decisions which may be heavily affected and constrained by other structural factors, such as the availability and prices of different types of dwellings, the labour market, as well social norms for example about how to live when having children. Decisions like this are also taken maybe only once or twice in a lifetime, again often in conjunction with having children, and then become pre-conditions for other behaviours that eventually become routinized.

4.2 Social norms

Because of the low internal consistency of the different evaluated norm statements (Table 1, Cronbach's α = 0.30) we discarded the idea of any over-arching pro-environmental social norm. Still, the specific pro-environmental social norms were found to have relatively high correlations with the corresponding GHG emissions, as was shown in Table 5. Four out of five statements had a stronger correlation with total emissions than what was the case for pro-environmental attitudes, even though the norm statements were directed towards specific domains of consumption.

An important issue here is, however, the statements themselves and what they actually capture. As described in Section 2.3.2, we used two different types of statements that the respondents were asked to agree or disagree with (scale 1-7). The more direct norm statements regarding what is believed to be expected by or desirable among significant others did not give very strong correlations with GHG emissions, which may be due an unwillingness to admit to be affected by others (Nolan et al, 2008). The descriptive statements, formulated as the behaviours of significant others, gave much stronger correlations. According to for example Cialdini et al (1990), descriptive norms do not motivate through beliefs about what is morally approved, but rather through providing evidence for what is a reasonable and effective behaviour. However, to some degree, people may of course also behave in the same way as their acquaintances because they *are* similar (age, education etc.). Hence, a reasonable interpretation is probably that people share behaviours with their friends and relatives, for different reasons, and that it may be difficult to disentangle how much of that is really caused by the normative influence.

It is difficult to draw any strong conclusions from these attempts to quantify the effect of social norms on GHG emissions. We see a need for more research in this field, both methodologically regarding how to measure this, and regarding what types of norms that are really important for GHG emissions, as well as how such norms can be changed. Some of the most important social norms in this respect may not even have environmental connotations. Norms concerning issues such as how to live when forming a family or what to consume if one starts to earn a lot of money may also be very important.

5. Conclusions

In this paper we have attempted to improve the understanding of the variance of GHG emissions from households by merging perspectives from different fields. The GHG emissions from around 1000 Swedish households have been surveyed together with sets of explanatory variables borrowed from consumption research, urban planning research and environmental psychology. The results point strongly toward explanations of variance that have to do with circumstances rather than motivations for pro-environmental behaviours. Net income was found to be the most important explanatory variable followed by physical parameters that describe what type of dwelling the household occupies and distances to work and public/commercial services. The results also indicate that the importance of motivational variables is subordinate to economic and physical circumstances. This result applies to the emissions generated by the consumption of individuals only and not to the overall transition towards long-term climate targets, which also requires support for climate policy.

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