The carbon footprint of Indian households

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Authors: Nicole Grunewald[1*], Mirjam Harteisen[2], Jann Lay[12], Jan Minx[3] and Sebastian Renner[2*]

Abstract

We estimate total emissions, which are attributed to the expenditure of one household during one year and identify the key consumption groups, which drive strong increases in household emissions when income is rising. First we apply input-output energy analysis in combination with household expenditure survey data from India for the year 2005; we calculate the carbon footprint of households by income groups and analyse the respective emission drivers. In a second step, we estimate income elasticities for a number of different consumption categories, again differentiating between households by income groups. By disaggregating household expenditure, we reveal how consumption patterns change when households become more affluent. We observe a disproportionately high increase in the demand for emission-intensive goods and services in comparison to less emission-intensive consumption categories.

[1]University of Göttingen, [2]GIGA German Institute of Global Area Studies, [3]Technical University of Berlin

*Corresponding Authors: ngrunew@gwdg.de, renner@giga-hamburg.de

Introduction

Household income in India has increased considerably in line with economic growth over the last decades. The ministry of statistics and programme implementation (MOSPI) reports that urban wages have been rising by 17.38 % between 2000 and 2005.[1] In line with wages also household expenditure has been rising especially in the urban areas were richer households are located. We expect a large share of households to pass the critical income level of 2 Dollars per day and we expect that carbon emissions from Indian households will account for a significant share of global greenhouse gas emissions (GHG) in the future. This rise in carbon emissions will be correlated with increasing direct and indirect energy requirements of households. However, energy consumption and carbon footprints vary with what and how households consume. Therefore, we first identify what we consider the Indian middle class in terms of their income and second we identify consumption patterns, their dynamics, and their respective carbon intensities for the different groups of households.

In a first step, we apply input-output (IO) energy analysis in combination with household expenditure survey data from India for the year 2004/05; we first calculate the carbon footprint of households by income groups and analyse the respective emission drivers. In a second step, we estimate income elasticities for a number of different consumption categories, again differentiating between households by income groups. The derived income elasticities for different consumption goods are then converted into carbon income elasticities. By disaggregating household expenditure, we reveal how consumption patterns change when households become more affluent. We observe a disproportionately high increase in the demand for emission-intensive goods and services in comparison to less emission-intensive consumption categories. Such a non-linear increase of carbon-intensive consumption is of great significance given that India has a large emerging middle class ready to spend its increasing discretionary income on a variety of emission-intensive consumption items.

The remainder of the paper is as follows. After the literature review we present the IO analysis as well as the expenditure analysis and clarify our definition of the middle class. In the results section we estimate the carbon footprint and determine the carbon intensive consumption items before we close with the conclusion.

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[1] Urban wages were rising only by 6.78 % between 2000 and 2005.

Literature Review

For an excellent survey on recent literature concerning input-output analysis and the carbon footprint, see Minx et al. (2009). Although our particular focus is on India and developing countries, most studies are for developed countries, which is due to reason of data availability.

Earlier carbon footprints for Indian households have been calculated by Parikh et al. (1997). Combining IO-data from 1989-90 and household data for the year 1987-88, their paper presents consumption pattern differences across income groups and their carbon dioxide implications. A main finding is that the rich have a more carbon intensive lifestyle with the urban emission levels being 15 times as high as those of the rural poor. Apart from carbon footprints, closely related energy requirements of Indian households have been calculated by Pachauri & Spreng (2002) for the years 1983-84, 1989-90 and 1993-94. Based on IO-analysis, they find that household energy requirements have significantly increased over time identifying growing income, population and increasing energy intensity in the food and agricultural sectors as the main drivers. Based on this analysis, Pachauri & Spreng (2002) presents cross-sectional variations in total household energy requirements. Using household consumption expenditure data for 1993-1994 matched with energy intensities calculated by Pachauri & Spreng (2002), an econometric estimation reveals income levels as the main factor determining variation in energy requirements across households.

Generally, carbon emissions, which are closely related to direct and indirect energy requirements of households, have been the subject of research since the 1970s. Herendeen and Tanaka (1976) use input-output and household expenditure data to calculate energy requirements of U.S. households. Additional to energy intensities, GHG intensities have been calculated by Lenzen (1998b) for Australian final consumption. Based on IO-analysis and including other GHGs than CO_2 such as CH_4, N_2O, CF_4 and C_2F_6, it is found that most of the GHG emissions are ultimately caused by household purchases.

Close to our approach, household expenditure data and IO derived carbon intensities have been used to calculate household carbon footprints for Australia Lenzen (1998a). Using IO derived carbon intensities from Lenzen (1998b) multiplied with expenditures on 376 commodities, it is the first study calculating carbon footprints on a disaggregated household level. Among the finding that per capita income is the main determinant of household energy and carbon requirements, it is found that rural households spend their income on more energy intensive commodities than a person from a metropolitan area on average. Drawing on a similar methodology for energy, Lenzen et al. (2006) focus on the role of income growth in a

cross-country analysis. Their motivation is to characterise household consumption patterns with respect to their environmental implications and hereby search for evidence on the Environmental Kuznets Curve (EKC). Their findings support previous research in the EKC energy literature, as energy requirements increase monotonically with household expenditure with no turning point observed.

In general there are several studies combining household expenditure data with IO derived carbon intensities to calculate household carbon footprints. Wier et. al (2001) analyse the carbon footprint of Danish households, identifying household characteristics with a significant influence on CO_2 emissions. Kerkhof et al. (2009) quantify CO_2 emissions of households in the Netherlands, UK, Sweden and Norway by combining a hybrid approach of process and input-output analysis with household expenditure data. Similar approaches recently published are Bin & Dowlatabadi (2005) and Weber & Matthews (2008), both focusing on US households. For the Netherlands, see Kerkhof et al. (2009).

Methodology

Deriving the Carbon Footprint

We combine energy IO analysis with household demand structure to estimate the carbon footprint for Indian households. Therewith, we can trace the carbon content of each final consumption item back to its intermediates and account for the direct as well as indirect emissions from consumption. We focus on carbon emissions from fossil fuels[2] since CO_2 emissions represent the largest share of GHG emissions covert under the Kyoto Protocol. The method which has been applied is based on Leontief (1970) and we follow the approach of Lenzen (1998b) and Lenzen et al. (2004).

In a first step we estimate the CO_2 intensities (by local currency unit) of each sector of the Indian economy. We apply a single region IO model based on the Global Trade Analysis Project (GTAP). By using a single region IO model we account for direct and indirect emissions from goods produced and consumed in India as well as for emissions from imported goods.[3]

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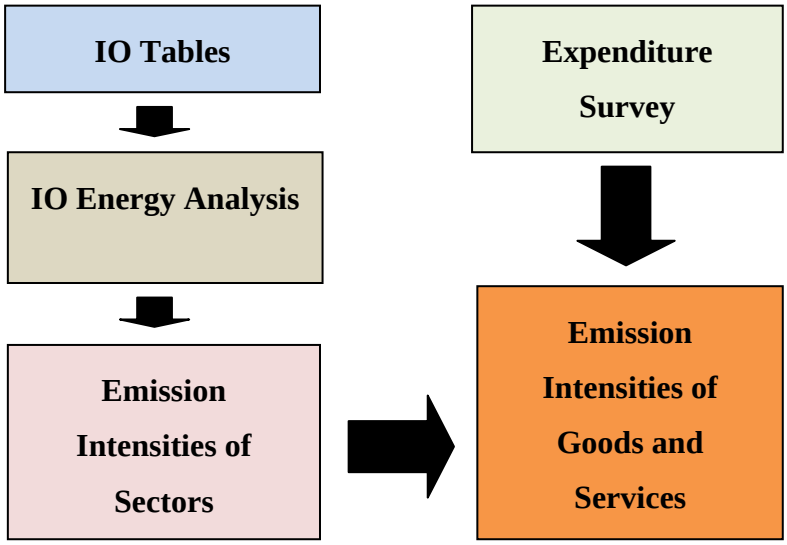
[2] The CO2 emissions are derived from following energy sources: coal, crude oil, natural gas, petroleum products, gas, electricity and gas. The share of renewable and nuclear energy in India's electricity was considerably low in 2005 so that we can claim to estimate emissions from the use of fossil fuels.

[3] The share of imported goods and services in the Indian GDP is constantly rising and accounted for 22% of GDP in 2005.

Figure 1: IO Energy Analysis with Expenditure Data



Source: After (Kok et al. 2006)

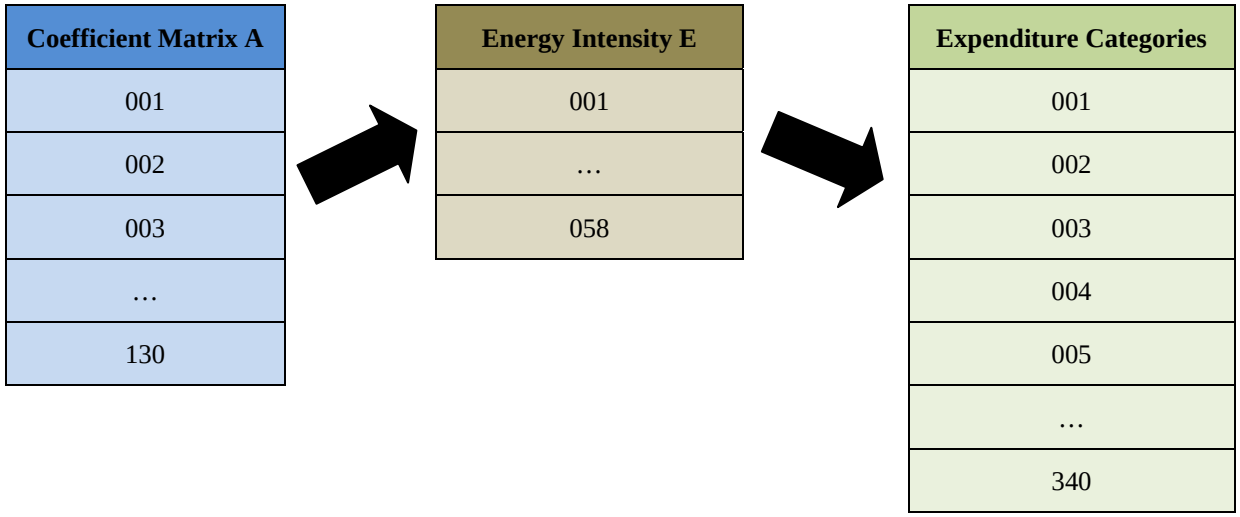
Figure 1 describes the process IO energy analysis. We use IO tables from the Indian Central Statistical Organisation (CSO) which provide us with an [jx1] vector of domestic output *x* by 130 industrial sectors *j*, a [jx1] vector of final demand *y* by 130 industrial sectors *j* (which includes imports). And a [jxj] matrix of the technical coefficients *A,* which reflect the input requirements of the *jth* sector of intermediates from other sectors measured in monetary units. We apply the simple technology assumption and assume that imported goods are produced with the same technology as local goods. Depending on the fuel type the CO_2 emissions per unit of fuel use are represented in the emission coefficient vector *c* [mx1]. The [mxj] energy use matrix E^{ind} represents the energy demand of the 58 sectors per monetary unit of intermediate output from other sectors and the energy use matrix E^{fd} represents the household's fuel use per monetary unit of final demand from 58 sectors.[4] Total emissions from consumption CO_2 would consist of direct CO_2^{fd} from final demand and indirect CO_2^{ind} emissions from energy use by each sector.

In Figure 2 the process of the data matching stages is outlined. In the first step we matched the 130 sectors of our IO tables with the energy use data, which is aggregated to 58 sectors in order to get the energy intensity matrix *E*. In a second step we match the 58 sector emission intensities with the corresponding expenditure categories from the household survey data. The data on household expenditure is rather disaggregated and we match the mayor 40 sub-

[4] The data by the GTAB energy volume data is disaggregated into 58 sectors, which were matched with the 130 sectors from the Indian IO tables.

expenditure categories and for some of the subgroups we disaggregate the data further and match it with the corresponding emission intensities.[5]

Figure 2: Data Matching Scheme



Source: Authors

In our model we consider a single region approach, which assumes that environmental and energy technology is the same as abroad. Therefore, we analyse the sum of direct and indirect emissions from industrial sectors. Direct emissions from final demand can be characterized as follows:

$$CO_2^{fd} = c' E^{fd} y \qquad (1)$$

where *c'* represents the inverse emissions coefficient vector, E^{fd} is the energy use matrix and *y* is the final demand vector.

Indirect emissions CO_2^{ind}, which are divided into emissions from domestic production for domestic final demand, emissions from imported intermediates and emissions from imported final demand (2).[6] The emissions by sector can be estimated by multiplying the demand of each sector represented as vector *y* with the transposed emissions coefficients vector *c* and the industrial energy use matrix E^{ind} as well as the with the domestic Leontief inverse $(I\text{-}A)^{-1}$:

$$CO_2^{ind} = c' E^{ind} \left[(I-A)^{-1} y_{\neq exp} + ((I-A_{tot})^{-1} - (I-A)^{-1}) y_{\neq exp} + (I-A_{tot})^{-1} y_{imp_{\neq exp}} \right] \qquad (2)$$

[5] For an overview on the emission intensities of each economic sector and our matched consumption category please refer to Appendix I

[6] Exports are excluded.

where $A_{tot}=A+A_{imp}$, $y_{tot}=y+y_{imp}$ and $y_{\neq exp}$ is domestic final demand and I represents an identity matrix and A is the technical coefficients matrix, which mirrors the contribution of the intermediates to one final output unit.

Direct and indirect emissions from consumption can be estimated by:

$$CO_2 = CO_2^{fd} + CO_2^{ind} \tag{3}$$

$$CO_2 = c' \left[E^{fd} y_{hh} + E^{ind} \left((I - A)^{-1} y_{\neq exp} + ((I - A_{tot})^{-1} - (I - A)^{-1}) y_{\neq exp} + \right. \right.$$

$$\left. \left. I - Atot - 1 yimp \neq exp \right. \right.$$

(4)

In order to estimate the household carbon footprint we multiply the carbon intensity per local currency unit of each industrial sector with the household expenditure for the respective category and sum up over all categories for each household. Therewith we gain the household carbon footprint CO_2^{hh} for each household in 2004/05 in kg of CO_2.

$$CO_2{}^{hh}{}_i = \sum_{i=649}^{j} \left(CO_2^{ind}{}_j * Exp_{ij} \right) \tag{5}$$

where i represents the household and j the different expenditure category.

Determinants of the Household Carbon Footprint

To analyse the role of rising incomes and household characteristics on the household carbon footprint, we proceed in two steps. In the first step, we regress the household income, which is proxied by total expenditure and various control variables X, which include: *Region, Household Size, Employment Type and Religion* on the household carbon footprint CO_2^{hh}.[7]

$$CO_2^{hh}{}_i = \alpha + \beta_1 Income_i + \beta_2 Controls_i + \varepsilon_i \tag{6}$$

Here income is proxied by total expenditure, hence it is a function of the household carbon footprint divided by the Carbon Intensities and we instrument income with an asset index as in a second step.

$$Income_i = \alpha + \beta_1 Asset\ Index_i + \varepsilon_i \tag{7}$$

$$CO_2^{hh}{}_i = \alpha + \beta_1 Income_i + \beta_2 Controls_i + \varepsilon_i \tag{8}$$

[7] The Method applied is ordinary least squares and two stage least squares for the instrumental variable regression.

Still our income variable is highly correlated with the carbon footprint and we replace it with income group and quintile dummies in a third step.

$$CO_2^{hh}{}_i = \alpha + \beta_1 Quintile1_i + \ldots + \beta_2 Quintile5_i + \beta_3 Controls_i + \varepsilon_i \quad (9)$$

Some of our control variables are highly correlated with the income and income quintiles, which leads us to divide regression (6) in two steps.

$$CO_2^{hh}{}_i = \alpha + \beta_1 Quintile1_i + \ldots + \beta_5 Quintile5_i + \varepsilon_i \quad (10)$$

$$\varepsilon_i = \alpha + \beta_1 Controls_i + \varepsilon_i \quad (11)$$

By estimating first the effect of the income quintiles on the carbon footprint and then explaining the residuals with the control variables we aim to reveal the true effect of the household characteristics on the carbon footprint.

While the estimated relationship is useful to separate the different determinants of the household carbon footprint, it has two important drawbacks. The first originates from a theoretical standpoint. Households target their consumption at goods which fulfil their needs, while CO_2 emissions represent an externality that is neither explicitly taken into account nor is it an aim to maximize the carbon footprint.[8] To deal with this wrong behavioural assumption in equation (3), we adopt a real household consumption perspective by estimating the demand elasticities for various consumption items. The second drawback of this first approach is the missing information about the consumption categories driving the household carbon footprint. We expect some categories to drive the carbon footprint more than others, revealing valuable information for further energy and climate mitigation policies.

Demand Analysis

Based on the Theory of Consumption by Deaton & Muellbauer (1980) demand functions derived from the utility maximization of the consumer depend on prices and income of these individuals. Since we do not have the data on prices of the household expenditure items we estimate these engel curves without prices, only dependent on income and socio-economic characteristics of the households.[9] Having no prices available, there is no necessity to meet the homogeneity restriction, with the adding-up restriction leading to linear budget constraints

[8] To some extent carbon emission are taken into account via energy prices leading to different prices of goods.

[9] We derived prices by dividing the household expenditure on a certain item through the number of items bought, but we received very unreliable results. The variance in the derived unit price was too large to be reliable.

as the necessary requirement left for the equation to estimate. The model to be estimated has the following form:

$$w_{ij} = \beta_0 + \beta_{1_{ij}} log\, y_i + \beta_{2_{ij}} X_i + \varepsilon_{ij} \quad (12)$$

where w_{ij} represents the share of total expenditures allocated to the jth consumption category by the *ith* household, $log\, y_i$ the income of household i in logs, X_i a vector with household characteristics and the error term ε_{ij}. With no income information available in the data, we follow the standard approach and use total expenditures per household as a proxy for income. The engel curves should preferably be estimated in a complete demand system to secure efficient estimates. However, our specification is in line with the adding-up restriction even if we estimate equation by equation by ordinary least squares.

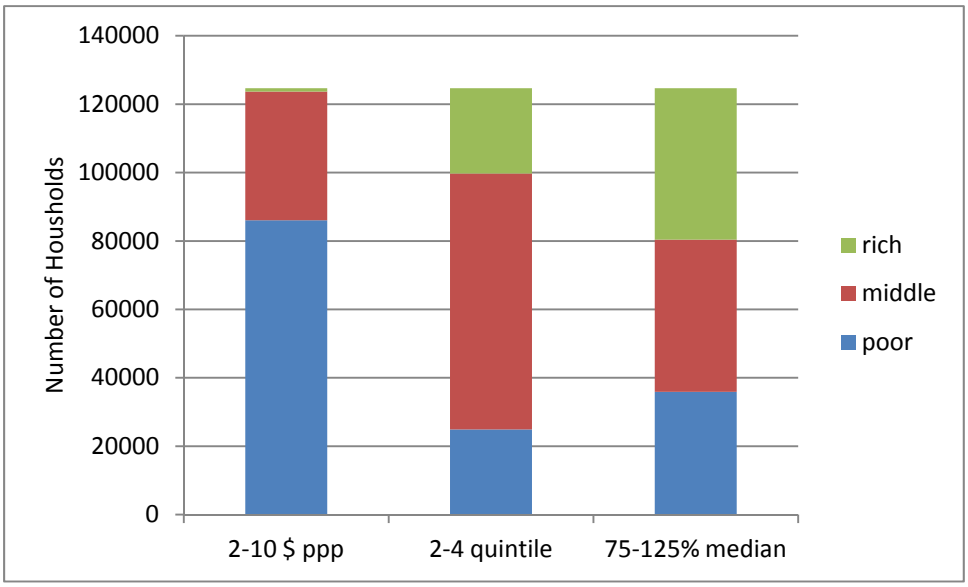
Besides the choice of functional form, which is a discussion on its own in the literature we are facing a couple of econometric problems, caused by the data and the estimated specification under consideration. The first problem, present in most household surveys is measurement error. A second problem is the potential endogeneity of our main explanatory variable. These common problems in demand estimation can be tackled by instrumental variable techniques.

To overcome the simultaneity bias which occurs by applying total expenditure as an independent variable which is a function of the dependent variable $w_{ij} = exp_{ij}/y_{ij} = exp_{ij}/exp_i$ we apply an asset index which we think represents long term household income.

Deaton (1997) points to another source of potential simultaneity bias, which is caused by richer household buying high quality products, which are more expensive. In other words as households get richer they do not consume more of a certain good and cause more carbon emissions but they consume higher quality goods which may not have to be related with higher carbon emissions than the lower quality items of the same consumption category. To control for this quality bias we split the sample for the analysis in rural and urban since we find that the majority of the urban households are living of less than 2 dollars a day. We further split our sample into low, middle and high income class following the approach of Banerjee & Duflo (2008) who define the middle class in developing countries as the people who live of between 2 and 10 dollars a day. This definition is an absolute and defers therewith from relative approaches such as taking the population between the 2nd and 4th income quintile Easterly (2001) or considering the population ranging between 75 and 125% of the Median

Birdsall et al. (2000) as middle class. Figure 3 highlights the differences when applying different classifications for the middle class.

Figure 3: Different Approaches to Define the Middle Class



Source: NSS 2006

Banerjee & Duflo (2008) point out that relative measures draw the wrong image of the society and the middle class would be rather large even though that people are living in poverty. By considering the households with an income within the 2nd and 4th income quintile half of the households in the sample would be considered middle class meanwhile still living with less than 2 dollars per day per person. We follow the approach of Banerjee & Duflo (2008) to divide our sample in rich, middle and poor households.

Data

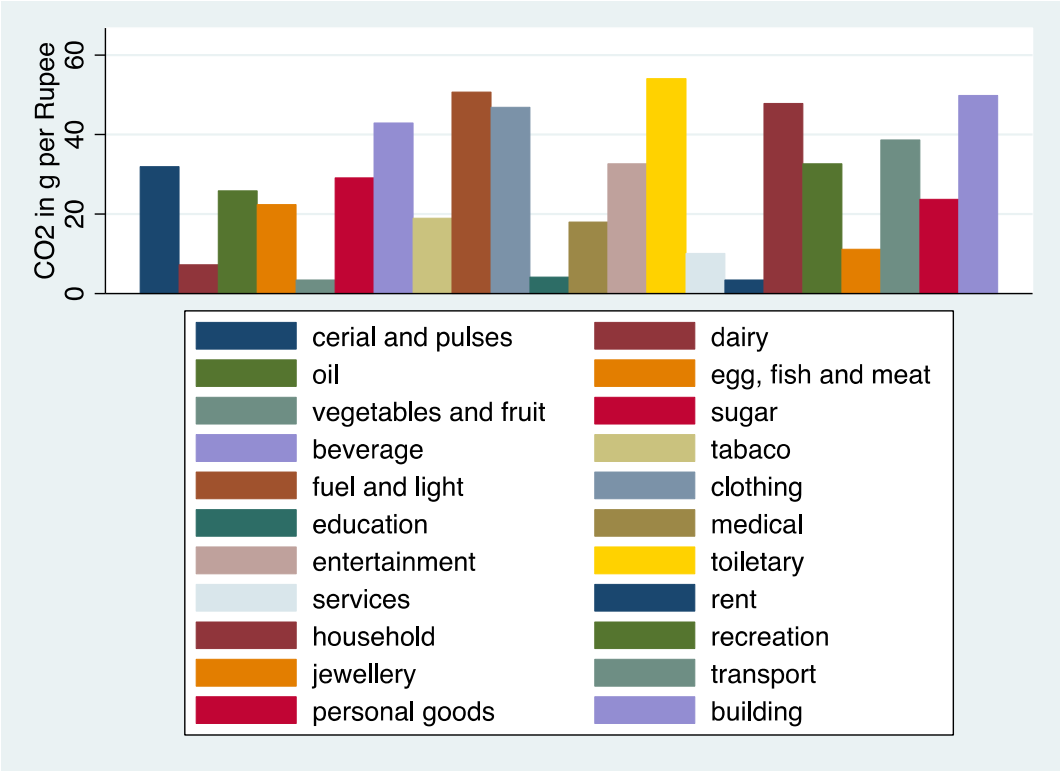
We apply IO data for 2004 from the Central Statistical Organisation in India. The IO tables are disaggregated into 130 economic sectors.[10] The data on energy demand per sector and the conversion into CO_2 emissions is derived from GTAP.[11] We estimated the emission

[10] For a list of the sectors and the corresponding emission intensities refer to Appendix I.

[11] The data on energy demand and CO_2 emissions by sectors is available upon request.

intensities for 58 economic sectors, which were matched with the household expenditure categories and are displayed in Figure 4.

Figure 4: Emission Intensities of Expenditure Sub-Groups



Source: CSO (2005) and NSS (2006).

Emission intensities vary strongly between the consumption categories with the highest emission intensity per currency unit for toiletry items as well as light and fuel. We observe the lowest emission intensities for vegetables and fruits as well as expenses on education.[12]

The household expenditure analysis is based on data from the National Sample Survey, which consists of data on expenditure of about 125000 households, which is disaggregated to around 340 consumption categories and 40 sub-categories.[13] The survey is a representative sample of the Indian economy and we apply the wave, which was conducted between 2004 and 2005. [14]

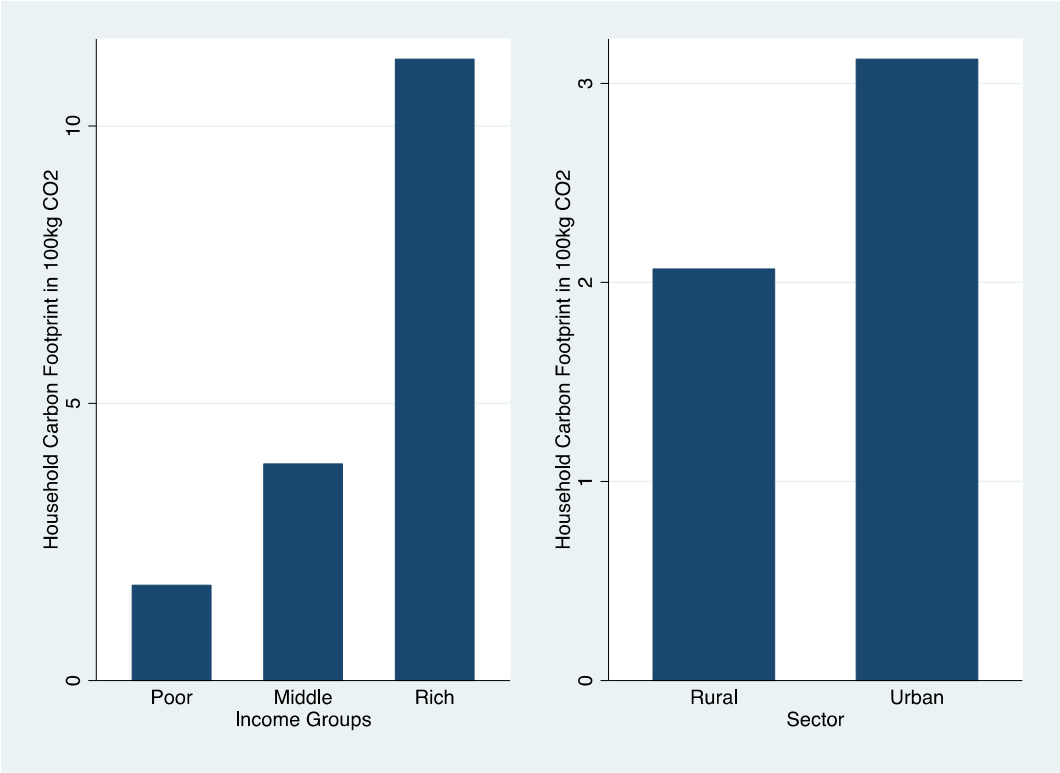
[12] Our Carbon Intensities by sector are much higher than the data by (N. Murthy et al. 1997)

[13] For an overview on household expenditure per sub-category refer to Appendix II.

[14] For summary statistics refer to Appendix III.

The households are to 64% located in urban areas and 69% of the households live of less than 2 dollars per person each day. The poor households are concentrated in rural areas. There are 11% of the households, which are headed by a woman. The average household size consists of 5 members, 46% of the households consist of 3 to 6 members and 39% are households with up 43 members.[15] The household heads are to 76% of Hindu, 12% of Muslim or 7% of Christian religion. The average years of schooling of the household head is 4 years and 30% of the household heads received only 1 year of schooling. The mean monthly per capita expenditure equals 887 Rupee; in urban areas households spent 300 Rupee more per person.[16]

Figure 5: Household Carbon Footprint by Income Group



Source: CSO (2005) and NSS (2006). Note: Poor less than 2 $ ppp, Middle 2-10 $ ppp and Rich 10 and more $ ppp per day.

When turning to the household carbon footprint, which consists of the sum of all expenses from the 40 sub expenditure categories multiplied with the respective emission intensities, we find large differences between the household carbon footprint of rich, middle and poor income households as displayed in Figure 5. Apparently, the carbon footprint of the high income group households 1.2 t CO_2 is about six times as high as the carbon footprint of the

[15] A household is defined as people sharing one kitchen.

[16] Our household expenditure is much lower than the data by (N. Murthy et al. 1997).

poor income group 0.2 t CO_2 and still three times as high as the one of the middle income group. The gab between urban and rural households is only 0.1t CO2 per year. Considering these large differences we want to analyse the drivers of the strong rise in the household emissions between the middle and high-income class. Therefore we analyse various carbon intensive consumption categories and estimate the income and carbon elasticities.

Results

Table 1 displays the results from the analysis of the household carbon footprint and its main determinants. In column (1) we include the logarithm of total household expenditure as a proxy for income in the analysis. Since total expenditure is a function of the household carbon footprint Exp=HHCO2/Carbon Intensities, we replace income (total expenditure) with an asset index as a proxy for income in column (2). The coefficients of our control variables remain the similar. Interestingly the relationship between income and emissions is non-linear with a turning point and at an income level of 125.774.352 Rupees per year and household, which is far out of sample with a maximum annual household income of 920.747 Rupees and a mean income of 46.561 Rupees per year. The variables in column (2) explain 95% of the variance in the household carbon footprint. Income itself, which represents total expenditure, explains 93% of the variance. In column (3) and (4) we replace income with dummy variables for income groups and quintiles.[17]

Table 1: Determinants of the household carbon footprint

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS 365	TSLS AI	OLS IG	OLS IQ	OLS IQ	OLS IQ
VARIABLES	LHHCO2	LHHCO2	LHHCO2	LHHCO2	LHHCO2	residid2
LYPCE365	1.681***	1.779***				
	(0.0254)	(0.0459)				
LYPCE365_sq	-0.0443***	-0.0477***				
	(0.00123)	(0.00216)				
rich_ppp			1.269***			
			(0.0144)			
middle_ppp			0.510***			
			(0.00228)			
quint_2				0.295***	0.247***	
				(0.00175)	(0.00460)	
quint_3				0.490***	0.402***	
				(0.00191)	(0.00462)	
quint_4				0.711***	0.567***	
				(0.00229)	(0.00467)	
quint_5				1.126***	0.832***	
				(0.00347)	(0.00486)	
urban	0.0296***	0.0276***	0.0565***	0.0520***		0.0566***
	(0.00112)	(0.00125)	(0.00234)	(0.00181)		(0.00191)

[17] The groups in column (3) are poor (2 USD ppp per day and person), middle (>2<10 USD ppp per day and person) and rich (<10 USD ppp per day and person). We further use income quintiles in column (4).

hhsize	0.0593***	0.0505***	0.360***	0.405***		0.374***
	(0.00220)	(0.00215)	(0.0137)	(0.0142)		(0.0132)
hhsize_sq	-0.00259***	-0.00201***	-0.0208***	-0.0231***		-0.0212***
	(0.000292)	(0.000262)	(0.00197)	(0.00204)		(0.00191)
hhsize_cu	4.83e-05***	3.56e-05***	0.000419***	0.000452***		0.000416***
	(1.04e-05)	(9.04e-06)	(7.31e-05)	(7.57e-05)		(7.09e-05)
LPG	0.0159***	0.00895***	0.138***	0.0474***		0.120***
	(0.00129)	(0.00161)	(0.00237)	(0.00202)		(0.00189)
gas	-0.000205	-0.00809	0.107***	-0.000653		0.0612***
	(0.00839)	(0.00870)	(0.0160)	(0.0125)		(0.0130)
dung	0.00252	0.00133	0.0412***	0.0183***		0.0328***
	(0.00164)	(0.00180)	(0.00364)	(0.00262)		(0.00269)
charcoal	-0.0316***	-0.0368***	0.0570***	-0.0195		0.0227
	(0.0114)	(0.0132)	(0.0217)	(0.0149)		(0.0157)
kerosine	-0.0281***	-0.0287***	-0.0253***	-0.0758***		-0.0528***
	(0.00229)	(0.00244)	(0.00478)	(0.00401)		(0.00406)
electricity	-0.0388***	-0.0487***	0.0980***	-0.0368*		0.0298
	(0.0143)	(0.0159)	(0.0229)	(0.0205)		(0.0206)
othercoc	-0.00220	-0.00197	-0.0113*	-0.000898		-0.000347
	(0.00235)	(0.00265)	(0.00599)	(0.00414)		(0.00442)
nococ	0.215***	0.219***	0.0521***	0.0582***		0.104***
	(0.00594)	(0.00621)	(0.0172)	(0.0159)		(0.0165)
selfempl	0.0101***	0.00837***	0.0452***	0.0249***		0.0338***
	(0.00104)	(0.00115)	(0.00220)	(0.00170)		(0.00178)
selfemplagri	-0.00469***	-0.00962***	0.0749***	0.0265***		0.0455***
	(0.00108)	(0.00125)	(0.00235)	(0.00177)		(0.00183)
agrilab	0.00515***	0.00876***	-0.0644***	0.00363		-0.0141***
	(0.00127)	(0.00141)	(0.00315)	(0.00228)		(0.00236)
employee	-0.00147	-0.00385**	0.0346***	0.00741***		0.0233***
	(0.00163)	(0.00180)	(0.00317)	(0.00270)		(0.00284)
hindu	-0.0181***	-0.00783***	-0.0627***	-0.0385***		-0.0610***
	(0.00224)	(0.00250)	(0.00442)	(0.00375)		(0.00393)
islam	-0.00389	0.00651**	-0.0441***	-0.0231***		-0.0437***
	(0.00251)	(0.00280)	(0.00509)	(0.00421)		(0.00440)
christ	-0.00945***	0.00127	-0.0430***	-0.0156***		-0.0300***
	(0.00322)	(0.00374)	(0.00627)	(0.00516)		(0.00546)
cerem	0.0272***	0.0204***	0.125***	0.0759***		0.116***
	(0.00334)	(0.00409)	(0.00624)	(0.00605)		(0.00652)
sex1	0.00130	0.00385**	-0.0436***	-0.0363***		-0.0404***
	(0.00135)	(0.00156)	(0.00345)	(0.00298)		(0.00303)
age1	-0.00236***	-0.00241***	0.00928***	0.00702***		0.00827***
	(0.000752)	(0.000828)	(0.00205)	(0.00187)		(0.00187)
age1_sq	7.65e-05***	7.43e-05***	-7.12e-05*	-9.75e-05**		-8.79e-05**
	(1.51e-05)	(1.66e-05)	(4.22e-05)	(3.85e-05)		(3.84e-05)
age1_cu	-5.72e-07***	-5.43e-07***	-1.54e-08	4.06e-07*		2.19e-07
	(9.71e-08)	(1.06e-07)	(2.69e-07)	(2.44e-07)		(2.44e-07)
edu1	0.000935**	9.71e-05	0.0265***	-0.00179**		0.00486***
	(0.000454)	(0.000527)	(0.000949)	(0.000755)		(0.000786)
edu1_sq	-0.000277***	-0.000371***	1.88e-05	0.00127***		0.00165***
	(4.70e-05)	(5.43e-05)	(8.96e-05)	(7.91e-05)		(8.21e-05)
Constant	-8.399***	-9.143***	2.931***	2.524***	4.095***	-1.378***
	(0.130)	(0.239)	(0.0344)	(0.0275)	(0.00340)	(0.0299)
Observations	124,001	101,373	124,001	124,001	124,643	124,001
R-squared	0.952	0.952	0.789	0.874	0.231	0.818

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, state dummies are included.

Moving from the lowest to the highest income quintile in column (4) increases the carbon footprint by 113%. Moving from the lowest to the second lowest income quintile increase the footprint by 30%. Being located in urban areas leads to 5% higher carbon footprint and another household member increases the carbon footprint by 38%. Nevertheless if the

household size exceeds 9 members[18] the carbon footprint declines again with another member. Households of Hindu religion exhibit a slightly lower footprint than Christian and Muslim households. If there was a ceremony such as a wedding or funeral held within the last year than the footprint is 8% higher. Female-headed households cause on average 4% less emissions. The age of the household head has a nonlinear effect of an inverse u-shape but the coefficients are very small just as the coefficients for the variable education of the household head, which show a u-shape relationship.

To analyse the unexplained variance of the household carbon footprint and to overcome the strong correlation between some of the explanatory variables such as the energy source for cooking and the profession of the household head with the household income we divide the analysis in two steps. First in column (5) we regress income on the household carbon footprint and second in column (6) we regress the control variables on the residuals from the first step.

In column (5) the coefficients of the income quintile dummies are slightly lower as the coefficients in column (4). Nevertheless we think that this separate regression as in column (6) is the preferred model since some of the control variables are strongly correlated with the income quintile dummies and yield higher coefficients in the separate analysis, which would result in the finding that they were slightly underestimated in model (4). Interestingly households, which use Low Pressure Gas (LPG) as mayor source of energy for cooking cause more emissions than those households, which use kerosene. Also households, which indicated that they do not have a cooking facility, cause 10% more emissions. Concerning the employment of the household head we find that households of labourers in agriculture cause slightly less emissions. Nevertheless, those households are also the poorest ones. The state dummies are always included. Apparently, households in the state Andaman and Nicobar Islands exhibit a higher carbon footprint than households from the other 69 states, which might be due to the higher income in this touristy state.

The analysis of income elasticities reveals some interesting results. Due to potential endogeneity reasons, we favour the 2SLS procedure with an asset index as an instrument for total expenditures. Results for urban, rural and all India are shown in Table 2. Negative income elasticities represent a declining expenditure share of the respective expenditure category with rising income. These inferior good categories such as food are in opposition to luxury goods such as entertainment or services. A main priority when households get richer

[18] Only 4.6% of the households have more than 9 members.

appears to be housing. With a doubling in income, the share of total expenditures spent for rent rises at about 17%. However, it has to be stressed that differences between rural and urban households can be significant. Increases in the spending for rent with rising income is mainly a phenomenon with urban households, rural households show only small spending responses towards higher rents. The classification into inferior, necessities and luxury goods mostly holds for rural and urban households for the same consumption category with the exception of toiletry and building. For the last two categories, this distinction can make quite a difference for carbon footprints, as both have high carbon intensities. While for all India, toiletry can be identified as an inferior good, although close to a necessity, it also shows up as an inferior good for urban households but as a luxury good for rural households. Ceteris paribus, this implies a faster rising carbon footprint for rural households.

Table 2: Income elasticities expenditure categories (2SLS)

	2SLS AI		2SLS URBAN		2SLS RURAL	
consumption share	coefficient	se	coefficient	se	coefficient	se
food	-0.165***	(0.00114)	-0.160***	(0.00193)	-0.154***	(0.00166)
tobacco	-0.00729***	(0.000215)	-0.00781***	(0.000361)	-0.00688***	(0.000319)
fuellight	-0.0107***	(0.000481)	-0.0110***	(0.000820)	-0.0173***	(0.000665)
clothing	-0.0121***	(0.000372)	-0.00662***	(0.000631)	-0.01000***	(0.000543)
education	0.0346***	(0.000639)	0.0332***	(0.00119)	0.0288***	(0.000829)
medical goods	0.00182**	(0.000912)	-0.00235	(0.00145)	0.0103***	(0.00138)
entertainment	0.0192***	(0.000205)	0.0192***	(0.000358)	0.0148***	(0.000279)
toiletry	-0.000847***	(0.000154)	-0.00417***	(0.000255)	0.000737***	(0.000232)
services	0.0406***	(0.000461)	0.0496***	(0.000822)	0.0353***	(0.000626)
rent	0.167***	(0.00212)	0.0912***	(0.00393)	0.00682***	(0.000419)
house	4.01e-05***	(2.07e-06)	5.16e-05***	(3.26e-06)	5.11e-05***	(3.36e-06)
recreation	4.40e-05***	(1.77e-06)	3.55e-05***	(2.83e-06)	5.53e-05***	(2.69e-06)
jewellery	4.70e-05***	(2.97e-06)	4.47e-05***	(4.41e-06)	7.56e-05***	(5.10e-06)
transport	0.000191***	(5.88e-06)	0.000216***	(9.35e-06)	0.000236***	(9.57e-06)
personal goods	1.50e-05***	(1.05e-06)	1.96e-05***	(2.13e-06)	1.02e-05***	(1.08e-06)
building	-2.92e-05***	(3.64e-06)	3.04e-05***	(5.43e-06)	-2.59e-05***	(5.61e-06)
N	101,662		37,813		63,849	

Source: NSS 2006 and CSO 2005

Additionally to the broad expenditure categories shown above, a more disaggregated view can be very helpful in understanding carbon footprint dynamics. In opposition to the aggregated results, a more detailed view on food categories reveals that some food items can be indeed considered luxury goods.

Table 3: Income elasticities food expenditure categories (2SLS)

	2SLS AI		2SLS URBAN		2SLS RURAL	
consumption share	coefficient	se	coefficient	se	coefficient	se

cerial & pulses	-0.142***	(0.000756)	-0.117***	(0.00119)	-0.155***	(0.00115)
dairy	0.0386***	(0.000810)	0.0510***	(0.00113)	0.0498***	(0.00132)
oil	-0.0153***	(0.000203)	-0.0136***	(0.000323)	-0.0153***	(0.000308)
egg_fish_meat	-0.0140***	(0.000434)	-0.0161***	(0.000684)	-0.0103***	(0.000654)
vegetables_fruits	-0.0274***	(0.000334)	-0.0220***	(0.000549)	-0.0292***	(0.000492)
sugar	-0.00557***	(0.000145)	-0.00418***	(0.000205)	-0.00352***	(0.000229)
beverages	0.00321***	(0.000690)	-0.0332***	(0.00171)	0.0120***	(0.000756)
N	101,662		37,813		63,849	

Source: NSS 2006 and CSO 2005

In Table 3 milk products (dairy) can be interpreted as luxury goods for both the rural and urban population, although the coefficient is not tremendously high with an increase of 0,4 % for every 10% increase in income. Surprisingly, as one could suspect before, other animal products such as egg, fish and meat are more inferior goods with a slightly declining share of total expenditures with rising income.

Looking at the mean of the income distribution like in the first column in Table 2, average effects for the whole population can be an interesting starting point. If one is additionally interested in carbon footprint changes of different income groups, greater heterogeneity in consumption behaviour can be revealed.[19] The poorest group of the population significantly reduces the share of food in total expenditures and increases consumption in most other categories. In general, no shift towards a sustainable consumption with low emission goods such as services or education can be observed. By moving up the income ladder, a considerable part of the additional income is spent on carbon intensive goods such as fuel and light.

Conclusion

In a first step we applied input output analysis matched with Indian household expenditure data to estimate the carbon footprint for Indian households. We analysed the determinants of the variation in the carbon footprints trying to find out what besides income is the major driver of Indian CO_2 emissions from consumption. In a second step we estimated the income elasticity of major consumption subgroups to point to consumption items, which are declared as luxury goods and which exhibit a high carbon intensity.

We find that income is indeed the major driver of household emissions but fuel types, which are used for cooking, have an impact on carbon footprints as well as age, gender, employment

[19] Results for income quintiles are shown in table Appendix VII and VIII.

type or religion of the household head. In this context female-headed households of Hindu religion emit on average slightly less than their counterparts. With the analysis of income elasticities of each consumption category we find that those categories, which are classified as luxury goods such as transport, medical goods, entertainment or services do not exhibit the highest carbon intensities, which leads us to the conclusion that the strong rise in the carbon footprint between the fourth and fifth income quintile is mainly due to the overall income increase. To give more insight on this matter one would have to have a look at the emission elasticities.

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Appendix

Appendix I – Emission Intensities by IO Sector

IO Cde	IO Description	kt CO2/100000 Rupee (Rs. Lakhs)
1	Paddy	0.004112514
2	Wheat	0.005150024
3	Jowar	0.001998897
4	Bajra	0.001521553
5	Maize	0.001716166
6	Gram	0.001352482
7	Pulses	0.001843026
8	Sugarcane	0.00199567
9	Groundnut	0.000933164
10	Coconut	0.001094785
11	Other oilseeds	0.001688505
12	Jute	0.000767761
13	Cotton	0.002064095
14	Tea	0.000488243
15	Coffee	0.001506113
16	Rubber	0.00116961
17	Tobacco	0.00088182
18	Fruits	0.000312899
19	Vegetables	0.000373043
20	Other crops	0.002218529
21	Milk and milk products	0.000723386
22	Animal services(agricultural)	0.002240727
23	Poultry & Eggs	0.00038531
24	Other liv.st. produ. & Gobar Gas	0.001052826
25	Forestry and logging	0.000397309
26	Fishing	0.000606924
27	Coal and lignite	0.003316245
28	Natural gas	0.005760873
29	Crude petroleum	0.00079371
30	Iron ore	0.003675439
31	Manganese ore	0.001162252
32	Bauxite	0.00655872
33	Copper ore	0.000977475
34	Other metallic minerals	0.003819088
35	Lime stone	0.003384801
36	Mica	0.001313169
37	Other non metallic minerals	0.000753466
38	Sugar	0.002909385
39	Khandsari, boora	0.002914822
40	Hydrogenated oil(vanaspati)	0.002583513

41	Edible oils other than vanaspati	0.001830671
42	Tea and coffee processing	0.005209347
43	Miscellaneous food products	0.004666592
44	Beverages	0.004290131
45	Tobacco products	0.001895663
46	Khadi, cotton textiles(handlooms)	0.005402276
47	Cotton textiles	0.006461528
48	Woolen textiles	0.004257129
49	Silk textiles	0.0027169
50	Art silk, synthetic fiber textiles	0.006005325
51	Jute, hemp, mesta textiles	0.005337591
52	Carpet weaving	0.003882589
53	Readymade garments	0.004105045
54	Miscellaneous textile products	0.004905571
55	Furniture and fixtures-wooden	0.002889844
56	Wood and wood products	0.002280736
57	Paper, paper prods. & newsprint	0.00732061
58	Printing and publishing	0.006650471
59	Leather footwear	0.002680479
60	Leather and leather products	0.002693471
61	Rubber products	0.005867202
62	Plastic products	0.00669696
63	Petroleum products	0.005068154
64	Coal tar products	0.006296996
65	Inorganic heavy chemicals	0.00644006
66	Organic heavy chemicals	0.005079818
67	Fertilizers	0.006147752
68	Pesticides	0.005936411
69	Paints, varnishes and lacquers	0.006142738
70	Drugs and medicines	0.005415864
71	Soaps, cosmetics & glycerin	0.005408317
72	Synthetic fibers, resin	0.005061084
73	Other chemicals	0.005631599
74	Structural clay products	0.013650674
75	Cement	0.016108776
76	Other non-metallic mineral prods.	0.012805394
77	Iron, steel and ferro alloys	0.00931503
78	Iron and steel casting & forging	0.010505635
79	Iron and steel foundries	0.008489451
80	Non-ferrous basic metals	0.003302273
81	Hand tools, hardware	0.004930313
82	Miscellaneous metal products	0.006259155
83	Tractors and agri. implements	0.005557207
84	Industrial machinery(F & T)	0.00385153
85	Industrial machinery(others)	0.003714747
86	Machine tools	0.004202782

87	Other non-electrical machinery	0.004237429
88	Electrical industrial Machinery	0.005155655
89	Electrical wires & cables	0.004981934
90	Batteries	0.005836697
91	Electrical appliances	0.005199852
92	Communication equipments	0.004088944
93	Other electrical Machinery	0.004878112
94	Electronic equipments(incl.TV)	0.003260319
95	Ships and boats	0.000670547
96	Rail equipments	0.005507866
97	Motor vehicles	0.005184593
98	Motor cycles and scooters	0.006261721
99	Bicycles, cycle-rickshaw	0.005540685
100	Other transport equipments	0.005560586
101	Watches and clocks	0.00238502
102	Medical, precision&optical instru.s	0.003419611
103	Jems & jewelry	0.001112014
104	Aircraft & spacecraft	0.000173823
105	Miscellaneous manufacturing	0.001335668
106	Construction	0.005032379
107	Electricity	0.060437653
108	Water supply	0.003468475
109	Railway transport services	0.010466244
110	Land tpt including via pipeline	0.004600846
111	Water transport	0.017015131
112	Air transport	0.006523075
113	Supporting and aux. tpt activities	0.005900578
114	Storage and warehousing	0.013685152
115	Communication	0.00236796
116	Trade	0.001434421
117	Hotels and restaurants	0.003031951
118	Banking	0.001128398
119	Insurance	0.002280669
120	Ownership of dwellings	0.000341209
121	Education and research	0.000411614
122	Medical and health	0.001798426
123	Business services	0.002431687
124	Computer & related activities	0.000885475
125	Legal services	0.000430641
126	Real estate activities	0.000745064
127	Renting of machinery & equipment	0.000271409
128	O.com, social&personal services	0.001008876
129	Other services	0.001450611
130	Public administration	3.99696E-06

Source: Authors estimation based on data from GTAP and CSO (2005)

Appendix II – Matched Carbon Emission Intensities with Consumption Categories

nsscode	nssdescription	match	
101	rice - PDS	1	
102	rice - other sources	1	
103	chira	1	
104	khoi, lawa	1	
105	muri	1	
106	other rice products	1	
107	wheat/atta - PDS	2	
108	wheat/atta - other sources	2	
110	maida	2	
111	suji, rawa	2	
112	sewai, noodles	1	
113	bread: bakery	2	
114	other wheat products	2	
115	jowar & products	3	
116	bajra & products	4	
117	maize & products	5	
118	barley & products	2	
120	small millets & products	4	
121	ragi & products	7	
122	other cereals		
129	cereal: s.t. (101-122)		mean
139	cereal substitutes: tapioca, jackfruit, etc.		mean
140	arhar, tur	6	
141	gram: split	6	
142	gram: whole	6	
143	moong	6	
144	masur	6	
145	urd	6	
146	peas	6	
147	soyabean	7	
148	khesari	7	
150	other pulses	7	
151	gram products	6	
152	besan	6	
153	other pulse products	7	
159	pulses & pulse products: s.t. (140-153)	7	
160	milk: liquid (litre)	21	
161	baby food	21	
162	milk: condensed/ powder	21	
163	curd	21	
164	ghee	21	
165	butter	21	
166	ice-cream	21	

167	other milk products	21	
169	milk & milk products: s.t.(160-167)	21	
170	vanaspati, margarine	40	
171	mustard oil	11	
172	groundnut oil	9	
173	coconut oil	10	
174	edible oil: others	41	
179	edible oil: s.t. (170-174)	40	
180	eggs (no.)	23	
181	fish, prawn	26	
182	goat meat/mutton	22	
183	beef/ buffalo meat	22	
184	pork	22	
185	chicken	23	
186	others: birds, crab, oyster, tortoise, etc.	23	
189	egg, fish & meat: s.t. (180-186)	22	
190	potato	19	
191	onion	19	
192	radish	19	
193	carrot	19	
194	turnip	19	
195	beet	19	
196	sweet potato	19	
197	arum	19	
198	pumpkin	19	
200	gourd	19	
201	bitter gourd	19	
202	cucumber	19	
203	parwal, patal	19	
204	jhinga, torai	19	
205	snake gourd	19	
206	papaya: green	19	
207	cauliflower	19	
208	cabbage	19	
210	brinjal	19	
211	lady's finger	19	
212	palak/other leafy vegetables	19	
213	french beans, barbati	19	
214	tomato	19	
215	peas	19	
216	chillis: green	19	
217	capsicum	19	
218	plantain: green	19	
220	jackfruit: green	18	
221	lemon (no.)	18	
222	garlic (gm)	19	

223	ginger (gm)	19	
224	other vegetables	19	
229	vegetables: s.t. (190- 224)	19	
230	banana (no.)	18	
231	jackfruit	18	
232	watermelon	18	
233	pineapple (no.)	18	
234	coconut (no.)	18	
235	guava	18	
236	singara	18	
237	orange, mausami (no.)	18	
238	papaya	18	
240	mango	18	
241	kharbooza	18	
242	pears, naspati	18	
243	berries	18	
244	leechi	18	
245	apple	18	
246	grapes	18	
247	other fresh fruits	18	
249	fruits (fresh): s.t.(230-247)	18	
250	coconut: copra	10	
251	groundnut	9	
252	dates	18	
253	cashewnut	9	
254	walnut	9	
255	other nuts	9	
256	raisin, kishmish, monacca, etc.	18	
257	other dry fruits	18	
259	fruits (dry): s.t. (250-257)		mean
260	sugar - PDS	38	
261	sugar - other sources	38	
262	gur	8	
263	candy, misri	39	
264	honey		
269	sugar: s.t. (260-264)	38	
279	salt	37	
280	turmeric (gm)		
281	black pepper (gm)		
282	dry chillies (gm)		
283	tamarind (gm)		
284	curry powder (gm)		
285	oilseeds (gm)		
286	other spices (gm)		
289	spices: s.t. (280-286)	20	
290	tea: cups (no.)	42	

291	tea: leaf (gm)	14	
292	coffee: cups (no.)	42	
293	coffee: powder (gm)	15	
294	ice		
295	cold beverages: bottled/canned (litre)	44	
296	fruit juice and shake (litre)	44	
297	coconut: green (no.)	44	
298	other beverages: cocoa, chocolate, etc.	44	
300	biscuits		
301	salted refreshments	44	
302	prepared sweets		
303	cooked meals (no.)		
304	cake, pastry		
305	pickles (gm)		
306	sauce (gm)		
307	jam, jelly (gm)		
308	other processed food		
309	beverages etc.: s.t. (290- 308)	44	
310	pan: leaf		
311	pan: finished (no.)		
312	supari (gm)		
313	lime (gm)		
314	katha (gm)		
315	other ingredients for pan (gm)		
319	pan: s.t. (310-315)		
320	bidi (no.)		
321	cigarettes (no.)	45	
322	leaf tobacco (gm)	45	
323	snuff (gm)		
324	hookah tobacco (gm)	45	
325	cheroot (no.)		
326	zarda, kimam, surti (gm)		
327	other tobacco products	45	
329	tobacco: s.t. (320-327)	45	
330	ganja (gm)		
331	toddy (litre)		
332	country liquor (litre)		
333	beer (litre)		
334	foreign liquor or refined liquor (litre)		
335	other intoxicants		
339	intoxicants: s.t. (330-335)		
340	coke	64	
341	firewood and chips		
342	electricity (std. unit)		
343	dung cake		
344	kerosene-PDS(litre)	63	

345	kerosene - other sources (litre)	63	
346	matches (box)		
347	coal	64	
348	LPG	63	
350	charcoal	64	
351	candle (no.)		
352	gobar gas		
353	other fuel		
359	fuel and light: s.t. (340-353)	63	
360	dhoti (metre)		
361	sari (metre)		
362	cloth for shirt, pyjama, salwar, etc. (metre)	47	
363	cloth for coat, trousers, overcoat, etc. (metre)		
364	chaddar, dupatta, shawl, etc. (no.)		
365	lungi (no.)		
366	gamchha, towel, handkerchief (no.)		
367	hosiery articles, stockings, under- garments, etc. (no.)		
368	ready-made garments (no.)		
370	headwear (no.)		
371	knitted garments, sweater, pullover, cardigan, muffler, scarf, etc. (no.)		
372	knitting wool, cotton yarn (gm)	48	
373	clothing: others		
374	clothing: second-hand		
379	clothing: s.t. (360-374)	54	
380	bed sheet, bed cover (no.)	47	
381	rug, blanket (no.)		
382	pillow, quilt, mattress (no.)		
383	cloth for upholstery, curtain, table- cloth, etc. (metre)		
384	mosquito net (no.)		
385	mats and matting (no.)		
386	cotton (gm)	47	
387	bedding: others		
389	bedding, etc.: s.t. (380-387)	47	
390	leather boots, shoes	59	
391	leather sandals, chappals, etc.	59	
392	other leather footwear	59	
393	rubber/ PVC footwear	61	
394	other footwear		
399	footwear: s.t. (390-394)	59	
400	books, journals	56	
401	newspapers, periodicals	58	
402	library charges		
403	stationery		
404	tuition and other fees (school, college, etc.)		
405	private tutor/ coaching centre		
406	other educational expenses		

409	education: s.t. (400-406)	121	
410	medicine	70	
411	X-ray, ECG, pathological test, etc.	102	
412	doctor's/surgeon's fee		
413	hospital & nursing home charges		
414	other medical expenses		
419	medical - institutional: s.t. (410-414)	122	
420	medicine	70	
421	X-ray, ECG, pathological test, etc.	102	
422	doctor's/surgeon's fee		
423	family planning		
424	other medical expenses		
429	medical - non-institutional: s.t. (420-424)	122	
430	cinema, theatre		
431	mela, fair, picnic		
432	sports goods, toys, etc.		
433	club fees		
434	goods for recreation and hobbies		
435	photography		
436	video cassette/ VCR/ VCP(hire)	94	
437	cable TV connection	94	
438	other entertainment		
439	entertainment: s.t. (430-438)	94	
440	spectacles		
441	torch		
442	lock		
443	umbrella, raincoat		
444	lighter (bidi/ cigarette/ gas stove)		
445	other goods for personal care and effects		
449	goods for personal care and effects: s.t. (440-445)		
450	toilet soap	71	
451	toothbrush, toothpaste, etc.		
452	powder, snow, cream, lotion	71	
453	hair oil, shampoo, hair cream	71	
454	comb		
455	shaving blades, shaving stick, razor		
456	shaving cream	71	
457	sanitary napkins 00 458 other toilet articles		
459	toilet articles: s.t. (450-458)	71	
460	electric bulb, tubelight		
461	batteries	90	
462	other non-durable electric goods		
463	earthenware		
464	glassware		
465	bucket, water bottle/ feeding bottle & other plastic goods		
466	coir, rope, etc.		

467	washing soap/soda	71	
468	other washing requisites		
470	agarbati		
471	flowers (fresh): all purposes		
472	insecticide, acid, etc.	68	
473	other petty articles		
479	sundry articles: s.t. (460-473)		
480	domestic servant/cook	123	
481	sweeper	123	
482	barber, beautician, etc.	123	
483	washerman, laundry, ironing	123	
484	tailor	123	
485	priest	128	
486	legal expenses	125	
487	postage & telegram	128	
488	telephone charges	128	
490	repair charges for non-durables	123	
491	grinding charges	123	
492	miscellaneous expenses	128	
493	pet animals (incl. birds, fish)	123	
494	other consumer services excluding conveyance		
499	consumer services excluding conveyance: s.t. (480-494)	128	
500	air fare	112	
501	railway fare	109	
502	bus/tram fare	97	
503	taxi, auto-rickshaw fare	97	
504	steamer, boat fare	111	
505	rickshaw (hand drawn & cycle) fare	99	
506	horse cart fare	22	
507	porter charges	128	
508	petrol	29	
510	diesel	29	
511	lubricating oil	29	
512	school bus/van	97	
513	other conveyance expenses		mean
519	conveyance : s.t. (500-513)		
520	house rent, garage rent (actual)		
521	residential land rent		
522	other consumer rent		
529	rent: s.t. (520-522)	120	
539	house rent, garage rent (imputed- urban only)	120	
540	water charges		
541	other consumer taxes & cesses 549		
549	consumer taxes and cesses: s.t. (540-541)		
550	bedstead		
551	almirah, dressing table		

552	chair, stool, bench, table		
553	suitcase, trunk, box, handbag and other travel goods		
554	foam, rubber cushion (dunlopillo type)		
555	carpet, daree & other floor mattings		
556	paintings, drawings, engravings, etc.		
557	other furniture & fixtures (couch, sofa, etc.)		
559	furniture & fixtures: s.t. (550-557)	55	
560	gramophone & record player	94	
561	radio	94	
562	television	94	
563	VCR/VCP/DVD	94	
564	camera & photographic equipment	94	
565	tape recorder, CD player	94	
566	gramophone record, audio/video cassette, etc.	94	
567	musical instruments		
568	other goods for recreation		
569	goods for recreation: s.t. (560-568)	94	
570	gold ornaments		
571	silver ornaments		
572	jewels, pearls	103	
573	other ornaments		
579	jewellery & ornaments: s.t. (570-573)	103	
580	stainless steel utensils	82	
581	other metal utensils	82	
582	casseroles, thermos, thermoware	82	
583	other crockery & utensils	82	
589	crockery & utensils: s.t. (580-583)	82	
590	electric fan	91	
591	air conditioner	91	
592	air cooler	91	
593	lantern, lamp, electric lampshade	91	
594	sewing machine	91	
595	washing machine	91	
596	stove	91	
597	pressure cooker/pressure pan	91	
598	refrigerator	91	
600	electric iron, heater, toaster, oven & other electric heating appliances	91	
601	other cooking/household appliances	91	
609	cooking and household appliances: s.t. (590-601)	91	
610	bicycle	99	
611	motor cycle, scooter	98	
612	motor car, jeep	97	
613	tyres & tubes	61	
614	other transport equipment	100	
619	personal transport equipment: s.t. (610-614)	97	
620	hearing aids & orthopaedic equipment		

621	other medical equipment		
629	therapeutic appliances : s.t. (620-621)	122	
630	clock, watch	101	
631	other machines for household work		
632	personal computer	115	
633	mobile phone handset	115	
634	any other personal goods		
639	other personal goods: s.t. (630-634)	115	
640	bathroom and sanitary equipment		
641	plugs, switches & other electrical fittings	89	
642	residential building & land (cost of repairs only)		
643	other durables (specify).....		
649	residential building, land and other durables : s.t. (640-643)	89	
659	**durable goods : total (559+569+579+589+609+ 619+629+639+649)**		mean

Source: NSS (2006)

Appendix III: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
hhfootprint	124643	106.4361	66.40098	0.4576798	2087.379
YPCE365	124643	46561.17	38017.26	171.6717	920746.8
asindex	101826	3.64E-09	1.86455	-2.380994	6.950526
rich_ppp	124643	0.0076057	0.0868789	0	1
middle_ppp	124643	0.3017658	0.459026	0	1
poor_ppp	124643	0.6906284	0.4622364	0	1
quint_1	124643	0.2000032	0.400004	0	1
quint_2	124643	0.2000032	0.400004	0	1
quint_3	124643	0.1999952	0.399998	0	1
quint_4	124643	0.2000032	0.400004	0	1
quint_5	124643	0.1999952	0.399998	0	1
urban	124643	0.363807	0.481096	0	1
hhsize	124643	4.891851	2.522351	1	43
LPG	124643	0.2830564	0.4504854	0	1
gas	124643	0.0018372	0.0428239	0	1
dung	124643	0.0511621	0.2203292	0	1
charcoal	124643	0.0009868	0.0313983	0	1
kerosine	124643	0.039922	0.1957768	0	1
electricity	124643	0.0011312	0.0336149	0	1
othercoc	124643	0.0181398	0.1334575	0	1
nococ	124643	0.0178189	0.1322933	0	1
selfempl	124643	0.2853269	0.4515718	0	1
selfemplagri	124643	0.2241281	0.4170085	0	1
agrilab	124643	0.0926967	0.2900082	0	1
employee	124643	0.1400319	0.3470215	0	1
hindu	124643	0.7641103	0.4245553	0	1
islam	124643	0.1186589	0.323388	0	1
christ	124643	0.0687644	0.2530541	0	1
cerem	124413	0.0206892	0.1423421	0	1
sex1	124643	0.112393	0.3158506	0	1
age1	124275	45.81869	13.46543	15	108
edu1	124590	4.165992	2.785841	1	11

Source: NSS (2006) and CSO (2005)

Appendix VI: Summary Statistics

	hhfoot~t	YPCE365	asindex	rich_ppp	middle~p	poor_ppp	quint_1	quint_2	quint_3	quint_4	quint_5	urban	hhsize
hhfootprint	1												
YPCE365	0.9050*	1											
asindex	0.5627*	0.5979*	1										
rich_ppp	0.2221*	0.3662*	0.1404*	1									
middle_ppp	0.3704*	0.4177*	0.5341*	-0.0576*	1								
poor_ppp	-0.4095*	-0.4836*	-0.5571*	-0.1308*	-0.9822*	1							
quint_1	-0.2912*	-0.2952*	-0.3822*	-0.0438*	-0.3287*	0.3347*	1						
quint_2	-0.1559*	-0.1847*	-0.2179*	-0.0438*	-0.3287*	0.3347*	-0.2500*	1					
quint_3	-0.0461*	-0.0839*	-0.0708*	-0.0438*	-0.3287*	0.3346*	-0.2500*	-0.2500*	1				
quint_4	0.0939*	0.0661*	0.1526*	-0.0438*	0.2670*	-0.2569*	-0.2500*	-0.2500*	-0.2500*	1			
quint_5	0.3993*	0.4978*	0.5232*	0.1751*	0.7191*	-0.7470*	-0.2500*	-0.2500*	-0.2500*	-0.2500*	1		
urban	0.1824*	0.1876*	0.3957*	0.0732*	0.2728*	-0.2846*	-0.1691*	-0.0902*	-0.0631*	0.0309*	0.2915*	1	
hhsize	0.5144*	0.3653*	0.0567*	-0.0791*	-0.2340*	0.2472*	0.1782*	0.0932*	0.0271*	-0.0568*	-0.2417*	-0.1011*	1
LPG	0.3875*	0.4129*	0.6913*	0.0930*	0.4765*	-0.4906*	-0.2860*	-0.2068*	-0.0898*	0.1247*	0.4579*	0.4368*	-0.0539*
gas	0.0280*	0.0306*	0.0416*	-0.0038*	0.0200*	-0.0191*	-0.0177*	-0.0097*	-0.0027*	0.0179*	0.0123*	-0.0285*	0.0168*
dung	0.0041*	-0.0079*	-0.1122*	-0.0178*	-0.0634*	0.0663*	0.0458*	0.0328*	0.0032*	-0.0156*	-0.0663*	-0.1194*	0.1020*
charcoal	-0.0017	-0.0038*	-0.0139*	-0.0028*	0.0005	0	-0.0119*	0.0028*	0.0079*	0.0009	0.0003	0.0240*	-0.0034*
kerosine	-0.0769*	-0.0645*	0.0283*	-0.0131*	0.0343*	-0.0316*	-0.0576*	-0.0091*	0.0188*	0.0339*	0.0140*	0.1950*	-0.0949*
electricity	0.0001	0.0022*	0.0259*	-0.0002	0.0195*	-0.0193*	-0.0132*	-0.0109*	-0.0013	0.0047*	0.0208*	0.0276*	-0.0132*
othercoc	-0.0475*	-0.0496*	-0.0348*	-0.0105*	-0.0584*	0.0600*	0.0650*	0.0254*	-0.0095*	-0.0346*	-0.0463*	-0.0459*	-0.0002
nococ	-0.0954*	-0.0878*	-0.0249*	0.0838*	0.0824*	-0.0976*	-0.0143*	-0.0452*	-0.0404*	-0.0187*	0.1185*	0.1155*	-0.2031*
selfempl	0.0864*	0.0648*	0.1205*	-0.0095*	0.0125*	-0.0107*	-0.0247*	0.0046*	0.0033*	0.0105*	0.0063*	0.1774*	0.0682*
selfemplagri	0.0306*	0.0114*	-0.1374*	-0.0293*	-0.1045*	0.1093*	-0.0168*	0.0473*	0.0715*	0.0208*	-0.1228*	-0.4064*	0.1678*
agrilab	-0.1916*	-0.1794*	-0.2429*	-0.0273*	-0.1761*	0.1800*	0.2268*	0.0531*	-0.0330*	-0.1013*	-0.1456*	-0.2417*	-0.0424*
employee	0.1557*	0.1753*	0.3030*	0.0599*	0.2604*	-0.2699*	-0.1482*	-0.0989*	-0.0584*	0.0324*	0.2731*	0.5336*	-0.0926*
hindu	-0.1440*	-0.1038*	-0.0265*	-0.0020*	-0.0558*	0.0558*	0.0655*	0.0282*	-0.0153*	-0.0394*	-0.0389*	-0.0149*	-0.0756*
islam	0.0387*	0.0077*	-0.0449*	-0.0136*	-0.0450*	0.0473*	0.0213*	0.0253*	0.0112*	-0.0106*	-0.0471*	0.0501*	0.0964*
christ	0.1057*	0.0840*	-0.0139*	0.0123*	0.0878*	-0.0895*	-0.0871*	-0.0501*	0.0128*	0.0540*	0.0704*	-0.0117*	-0.0081*
cerem	0.1263*	0.1184*	0.0419*	0.0393*	0.0511*	-0.0581*	-0.0405*	-0.0296*	-0.0017	0.0150*	0.0567*	-0.0109*	0.0366*
sex1	-0.1176*	-0.0936*	-0.0497*	0.0104*	0.0072*	-0.0091*	-0.0001	-0.0103*	-0.0006	-0.0015	0.0124*	0.0209*	-0.1742*
age1	0.2217*	0.1882*	0.1263*	0.0048*	0.0390*	-0.0397*	-0.0619*	-0.0113*	0.0150*	0.0288*	0.0292*	-0.0407*	0.2059*
edu1	0.3183*	0.3626*	0.5164*	0.1325*	0.4186*	-0.4406*	-0.2856*	-0.1709*	-0.0676*	0.0958*	0.4283*	0.2576*	-0.0891*

Source: NSS (2006) and CSO (2005), Note: * indicates 5% significance level.

Appendix VI: Summary Statistics Continued

	LPG	gas	dung	charcoal	kerosine	electr~y	othercoc	nococ	selfempl	selfem~i	agrilab	employee
LPG	1											
gas	-0.0270*	1										
dung	-0.1459*	-0.0100*	1									
charcoal	-0.0197*	-0.0013	-0.0073*	1								
kerosine	-0.1281*	-0.0087*	-0.0474*	-0.0064*	1							
electricity	-0.0211*	-0.0014	-0.0078*	-0.0011	-0.0069*	1						
othercoc	-0.0854*	-0.0058*	-0.0316*	-0.0043*	-0.0277*	-0.0046*	1					
nococ	-0.0846*	-0.0058*	-0.0313*	-0.0042*	-0.0275*	-0.0045*	-0.0183*	1				
selfempl	0.1006*	-0.0184*	-0.0116*	0.0090*	0.0151*	-0.0017	0.0108*	-0.0562*	1			
selfemplagri	-0.2159*	0.0511*	0.0953*	-0.0144*	-0.1010*	-0.0152*	-0.0178*	-0.0705*	-0.3396*	1		
agrilab	-0.1881*	-0.0092*	0.0306*	-0.0092*	-0.0510*	-0.0091*	0.0648*	-0.0408*	-0.2020*	-0.1718*	1	
employee	0.3514*	-0.0162*	-0.0808*	0.0035*	0.1161*	0.0325*	-0.0344*	0.0807*	-0.2550*	-0.2169*	-0.1290*	1
hindu	-0.0122*	0.0080*	-0.0066*	-0.0217*	0.0039*	-0.0021*	-0.0038*	0.0063*	-0.0358*	-0.0098*	0.0586*	0.0211*
islam	-0.0542*	-0.0123*	0.0090*	-0.0068*	0.0310*	0.0032*	0.0230*	0.0029*	0.0951*	-0.0485*	-0.0291*	-0.0281*
christ	0.0497*	-0.0006	-0.0607*	0.0480*	-0.0263*	0.0031*	-0.0355*	-0.0052*	-0.0455*	0.0407*	-0.0523*	0.0169*
cerem	0.0252*	0.0056*	-0.0053*	-0.0009	-0.0187*	-0.0032*	-0.0058*	-0.0175*	-0.0013	0.0188*	-0.0225*	0.0008
sex1	-0.0101*	-0.0093*	-0.0290*	0.0115*	0.0129*	-0.0014	0.0032*	0.0122*	-0.0756*	-0.0526*	0.0061*	-0.0220*
age1	0.0655*	0.0206*	0.0042*	-0.0090*	-0.0745*	-0.0060*	-0.0104*	-0.1344*	-0.0209*	0.1260*	-0.0603*	-0.0563*
edu1	0.4568*	0.0157*	-0.0693*	-0.0008	-0.0070*	0.0211*	-0.0572*	0.0654*	0.0280*	-0.1327*	-0.2172*	0.2827*

Source: NSS (2006) and CSO (2005), Note: * indicates 5% significance level.

Appendix VI: Summary Statistics Continued

	hindu	islam	christ	cerem	sex1	age1	edu1
hindu	1						
islam	-0.6604*	1					
christ	-0.4891*	-0.0997*	1				
cerem	-0.0160*	0.001	0.0184*	1			
sex1	-0.0175*	0.0149*	0.0160*	-0.0061*	1		
age1	0.0048*	-0.0223*	0.0107*	0.0207*	0.0915*	1	
edu1	0.0114*	-0.0839*	0.0831*	0.0247*	-0.1773*	-0.1433*	1

Source: NSS (2006) and CSO (2005), Note: * indicates 5% significance level.

Appendix VII: Income elasticities income quintiles

	2SLS Quint1		2SLS Quint2		2SLS Quint3		2SLS Quint4		2SLS Quint5	
consumption share	coefficient	se	coefficient	se	coefficient	se	coefficient	se	coefficient	se
food	-0.575***	(0.0300)	-2.286***	(0.149)	-2.172***	(0.121)	-1.184***	(0.0462)	-0.443***	(0.0122)
tobacco	-0.0309***	(0.00383)	-0.305***	(0.0238)	-0.294***	(0.0198)	-0.156***	(0.00773)	-0.0334***	(0.00170)
fuellight	0.109***	(0.00936)	0.340***	(0.0409)	0.277***	(0.0315)	0.0950***	(0.0130)	0.0315***	(0.00322)
clothing	0.0787***	(0.0105)	0.0502**	(0.0244)	0.0470**	(0.0193)	0.0406***	(0.00916)	0.0132***	(0.00220)
education	0.0724***	(0.00614)	0.606***	(0.0450)	0.701***	(0.0434)	0.478***	(0.0216)	0.121***	(0.00594)
medical goods	-0.0628***	(0.00901)	-0.358***	(0.0480)	-0.644***	(0.0567)	-0.555***	(0.0343)	-0.124***	(0.00880)
entertainment	0.0728***	(0.00399)	0.389***	(0.0259)	0.393***	(0.0218)	0.200***	(0.00796)	0.0353***	(0.00159)
toiletry	0.0802***	(0.00537)	0.146***	(0.0134)	0.0821***	(0.00924)	0.0247***	(0.00377)	-0.00216***	(0.000805)
services	0.0266***	(0.00414)	0.232***	(0.0242)	0.445***	(0.0287)	0.383***	(0.0165)	0.187***	(0.00545)
rent	0.783***	(0.0410)	4.044***	(0.270)	3.452***	(0.199)	1.786***	(0.0763)	0.446***	(0.0168)
house	1.20e-05	(1.29e-05)	3.79e-05	(5.90e-05)	0.000124*	(6.42e-05)	8.14e-05*	(4.22e-05)	0.000115***	(1.45e-05)
recreation	8.28e-05***	(1.26e-05)	0.000558***	(7.74e-05)	0.000750***	(8.34e-05)	0.000198***	(3.31e-05)	1.61e-05	(1.18e-05)
jewellery	1.30e-05	(1.04e-05)	0.000162***	(6.00e-05)	-8.30e-06	(7.55e-05)	-2.65e-05	(5.95e-05)	-1.42e-05	(2.78e-05)
transport	0.000140***	(1.50e-05)	0.00119***	(0.000101)	0.00174***	(0.000122)	0.00126***	(7.26e-05)	0.00103***	(4.77e-05)
personal goods	2.45e-06*	(1.41e-06)	1.40e-05	(1.50e-05)	5.22e-05	(3.30e-05)	6.70e-05***	(1.74e-05)	8.33e-05***	(9.30e-06)
building	-0.000549***	(3.62e-05)	-0.00256***	(0.000209)	-0.00166***	(0.000156)	-0.00103***	(0.000103)	-6.91e-05**	(3.17e-05)
	20,582		20,717		20,225		19,899		20,358	

Appendix VIII: Income elasticities income quintiles food categories

	2SLS Quint1		2SLS Quint2		2SLS Quint3		2SLS Quint4		2SLS Quint5	
consumption share	coefficient	se	coefficient	se	coefficient	se	coefficient	se	coefficient	se
cerial & pulses	-0.692***	(0.0300)	-1.508***	(0.0988)	-1.117***	(0.0628)	-0.445***	(0.0188)	-0.0789***	(0.00324)
dairy	0.166***	(0.0110)	0.629***	(0.0629)	0.778***	(0.0610)	0.429***	(0.0275)	0.110***	(0.00599)
oil	-0.0117***	(0.00393)	-0.0729***	(0.0155)	-0.0194	(0.0119)	-0.000673	(0.00538)	-0.00929***	(0.00111)
egg_fish_meat	-0.00398	(0.00657)	-0.351***	(0.0377)	-0.638***	(0.0428)	-0.377***	(0.0183)	-0.0681***	(0.00310)
vegetables_fruits	-0.112***	(0.00757)	-0.513***	(0.0383)	-0.438***	(0.0288)	-0.195***	(0.0106)	-0.0212***	(0.00199)
sugar	0.0130***	(0.00280)	0.0465***	(0.0116)	0.0220**	(0.00860)	0.00669*	(0.00370)	-0.00274***	(0.000690)
beverages	0.139***	(0.0107)	0.0184	(0.0304)	-0.245***	(0.0335)	-0.340***	(0.0242)	-0.323***	(0.0137)
N	20,582		20,717		20,225		19,899		20,358	