

PhD Workshop in Economics
School of Economics and Management
University of Minho

Do Philippine Households Lead a Carbon Intensive Lifestyle?

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Before we start, where is Philippines?



Population: 92.3 mil (2010)

Ave household size: 4.68 (2008)

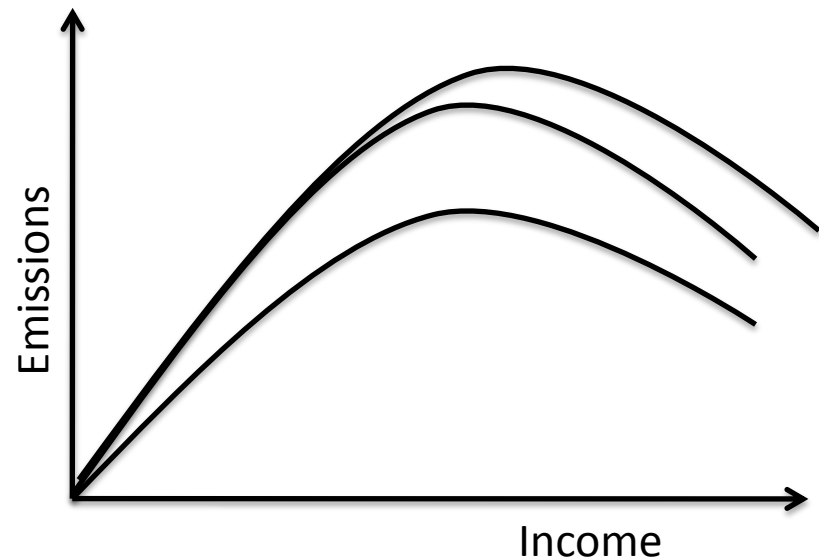
GDP percap (PPP) : 4,214 US\$ (2012)

Land: 7,100 + islands (300,000 sq km)



Introduction

- Environmental Kuznets Curve (EKZ)
 - Proposes an inverse U formed relationship between per-capita income and environmental degradation.
 - For a given society, the environmental pressure is expected to increase in the early stages of growth, but eventually to reach a peak and decrease as income exceeds a certain level (the turning point).



Introduction

- By consuming goods and services, households directly and indirectly contribute to CO₂ rising emissions
- In US more than 80% of the energy used and CO₂ emitted is a consequence of consumer demands and economic activities to support these demands (Bin & Dowlatabad, 2005)
- Girod & de Haan (2010) - households exert an important influence on total greenhouse gas and their consumption behavior is of interest in evaluations of climate policy options and projections of future emission paths
- However, limited evidence is available from developing countries



Research questions

- Which household expenditure items are more carbon intensive or less carbon intensive?;
- What is the characteristic of household carbon footprint? How does it differ in terms of location, age, gender, education level, & household size?; and
- How does income affects household carbon footprint? How does carbon footprint changes as households get affluent?



Literature review

- Parikh (1997) examines direct & indirect CO₂ emissions due to consumption of income classes in India
 - consumption of rich is oriented towards energy using sectors like electricity and transport
- Lenzen (1998) living means consuming and consuming requires producing items which cause depletion of resources and emissions of greenhouse gases.
 - used input-output and household expenditure in calculating the Australian household carbon footprints
 - consumption of petrol for cars, household electricity, meat and dairy products, and holidays involving air transport



Literature review

- Kenny & Gray (2009) found out that the average annual Irish household emission comprises 42.2% related to home energy use, 35.1% to transport, 20.6% to air travel and other fuel intensive leisure activities
- Lenzen *et al* (2006) analyze the effect of income growth on household energy requirements in Australia, Brazil, Denmark, India and Japan.
 - data does not support the hypothesis of a Kuznets curve, energy demand increase monotonically with household expenditure and no turning point is not observed.



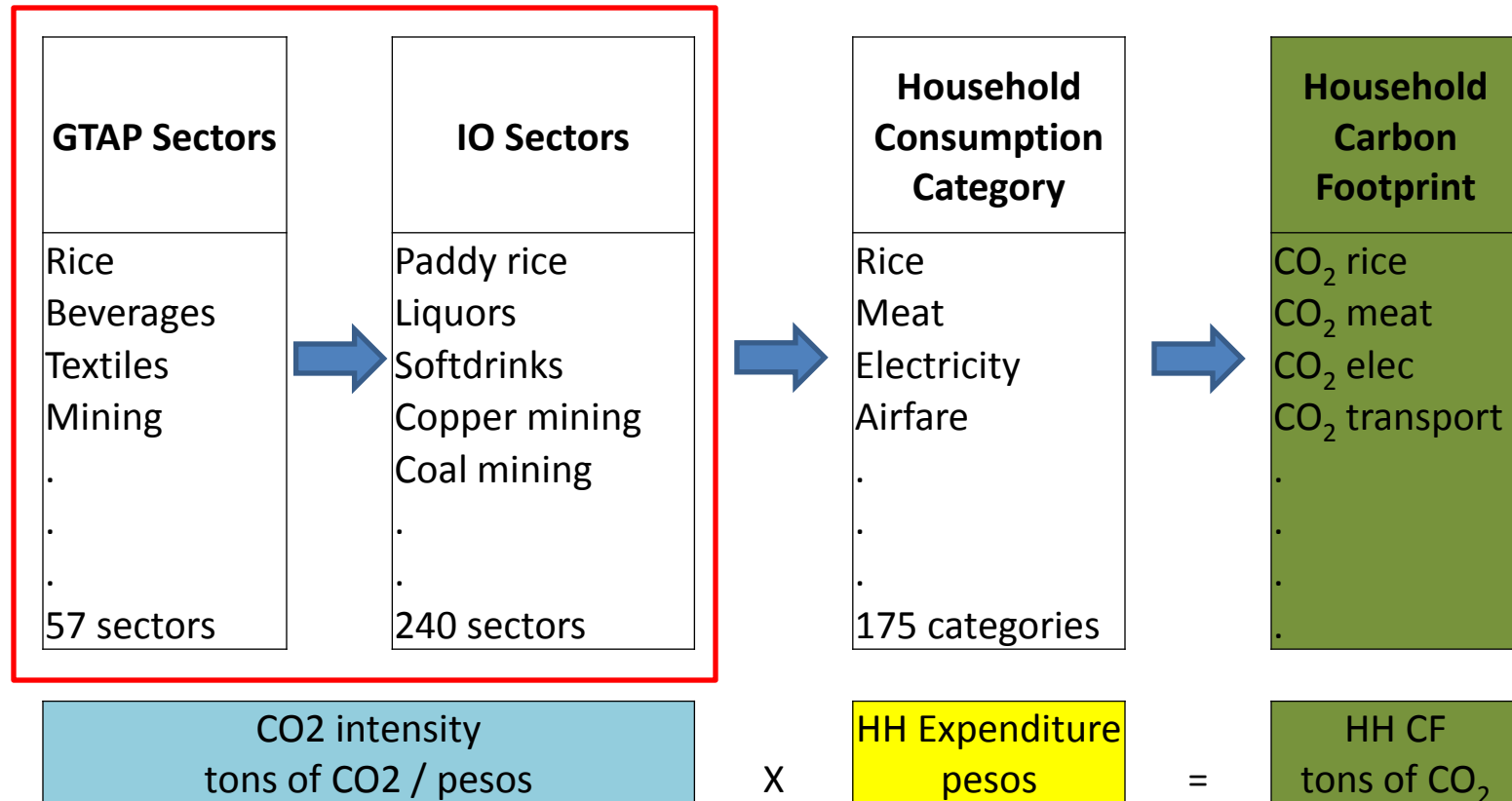
Methodology

1. Extract CO₂ emission intensity using the Global Trade Analysis Project (GTAP)'s CO₂ emission coefficient and Philippine Input Output Table year 2000 (ktons of CO₂ / 1000 pesos) (Lenzen 1998, Minx *et al* 2010, Grunewald *et al* 2012)
2. Match CO₂ emission intensity with household consumption category from household expenditure survey

$$hhCO2 = \sum_j^n (CO2 * Consumption_Cat_j)$$



Process flow and matching



Determinants of household carbon footprint

$$hhCO2_i = \beta_0 + \beta_{1i}income_i + \beta_{x_i}hh_char_i + \beta_{y_i}regdum_i + u_i$$

where:

hhCO2_i = log of household carbon footprint

income_i = measured as the log of total household expenditure or total household income

hh_char_i = household characteristics such as
age of household head,
educational attainment,
household size,
location (urban & rural)
marital status
gender of household head

regdum_i = regional dummies

u_i = is the error term



Results

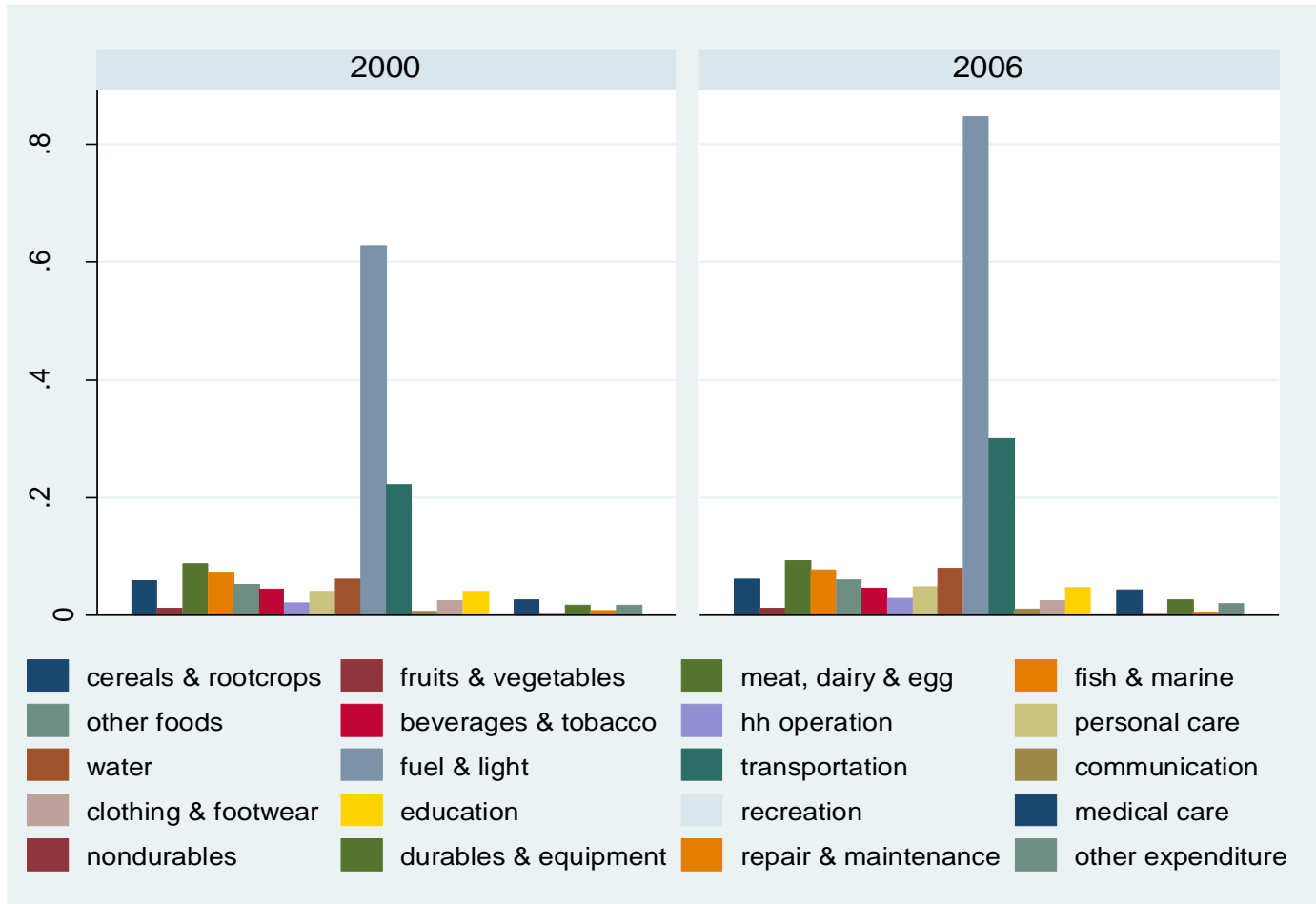
Top 20 and bottom 20 carbon intensive sectors

| Highest CO ₂ Emitting Sectors | CO ₂ Emission Intensity (g CO ₂ /peso) |
|---|--|
| Chromite mining | 158.8611 |
| Electricity | 157.2655 |
| Manufacture of structural concrete products | 78.4560 |
| Coal mining | 77.9721 |
| Manu. of other non-metallic mineral products | 76.0676 |
| Cement manufacture | 72.5321 |
| Manufacture of other glass and glass products | 72.0594 |
| Air transport | 71.1750 |
| Water | 67.4639 |
| Manufacture of glass container | 63.8897 |
| Railway transport | 63.1313 |
| Manufacture of structural clay products | 57.9100 |
| Tour and travel agencies | 57.2530 |
| Activities of other transport agencies | 55.2023 |
| Manufacture of ice, except dry ice | 53.6820 |
| Manu. of pottery, china and earthenwares | 53.4887 |
| Public utility cars and taxicab operation | 52.6268 |
| Road freight transport | 52.4432 |
| Jeepney, tricycles and other road transport | 52.1624 |
| Bus line operation | 51.3768 |

| Lowest CO ₂ Emitting Sectors | CO ₂ Emission Intensity (g CO ₂ /peso) |
|---|--|
| Citrus fruits | 3.3846 |
| Carabao | 3.3390 |
| Rice and corn milling | 3.3026 |
| Forestry | 3.2852 |
| Manufacture of semi-conductor devices | 3.0416 |
| Cattle | 2.7612 |
| Tobacco | 2.6526 |
| Leafy and stem vegetables | 2.6091 |
| Manu. of parts & supplies for radio, TV, comm | 2.6046 |
| Palay | 2.5977 |
| Manu. of radio & TV sets, sound recording | 2.5782 |
| Pineapple | 2.2363 |
| Mango | 2.2189 |
| Corn | 2.0624 |
| Other fruits and nuts | 1.7225 |
| Manu. of metal and wood-working machinery | 1.5920 |
| Ownership of dwellings | 1.4512 |
| Coconut including copra making in the farm | 1.2173 |
| Other vegetables, tubers and root crops | 1.1528 |
| Other agricultural crops | 0.7242 |



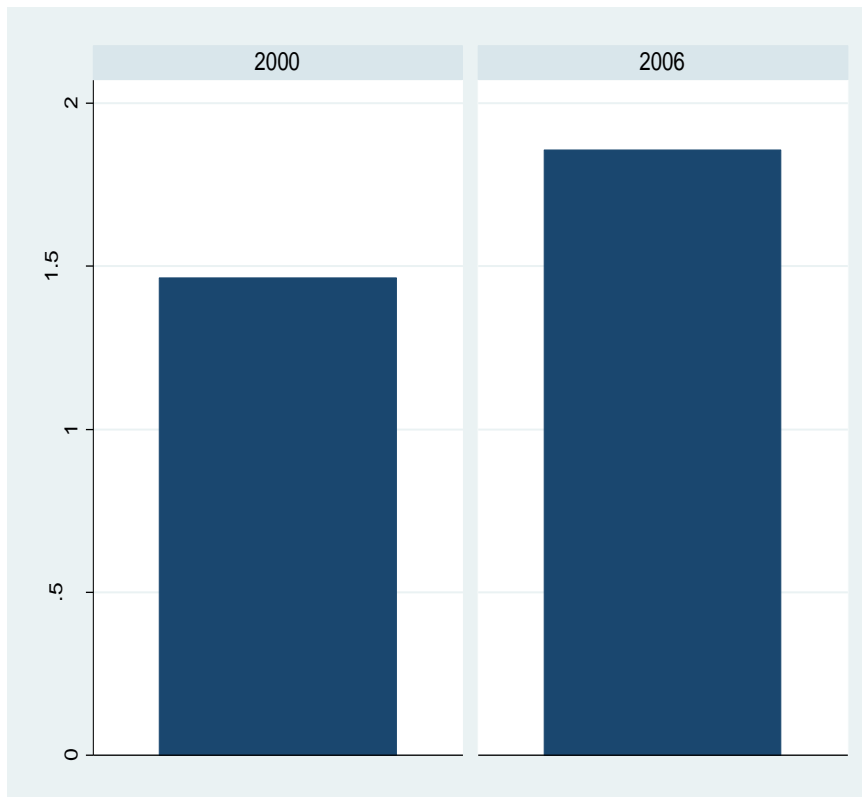
Characteristics of household CO₂ emission



CO₂ emission of expenditure category



But wait, is the result comparable?

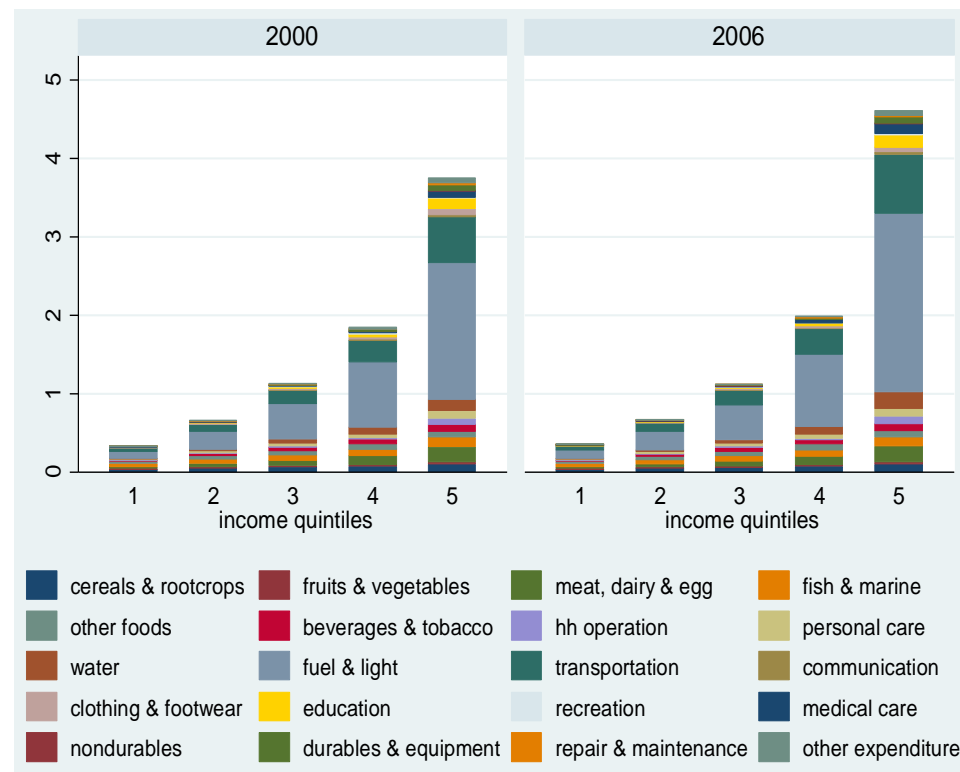
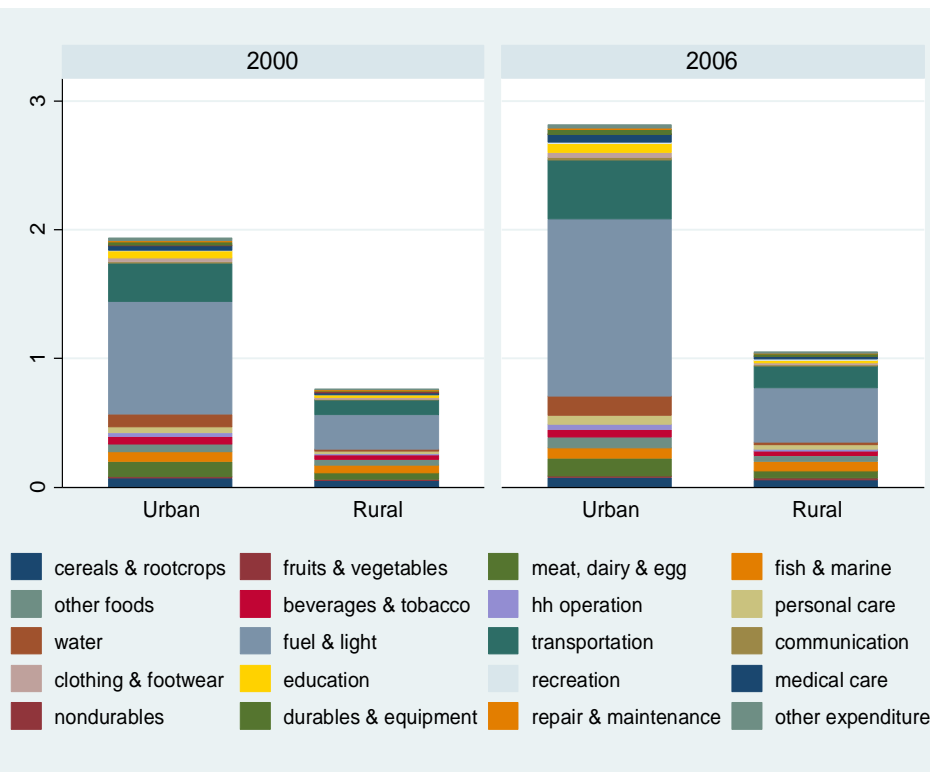


Philippine household emission

| Country | HH CO2 (tons) | Year | Source |
|-------------|---------------|---------------------|---------------------------|
| Philippines | 1.4 | 2000 | own computation |
| | 1.8 (2.1) | 2006 (not deflated) | own computation |
| India | 2.03 | 2004 | Grunewald et al (2012) |
| | 3.08 | 2009 | Grunewald et al (2012) |
| China | 6.7 | 2002 | Li & Wang (2010) |
| Germany | 15.4 | 2009 | Price (2010) |
| UK | 21.5 | 2004 | Druckman & Jackson (2009) |
| USA | 50.0 | 2004 | Weber & Matthews (2008) |



Characteristics of household CO₂ emission

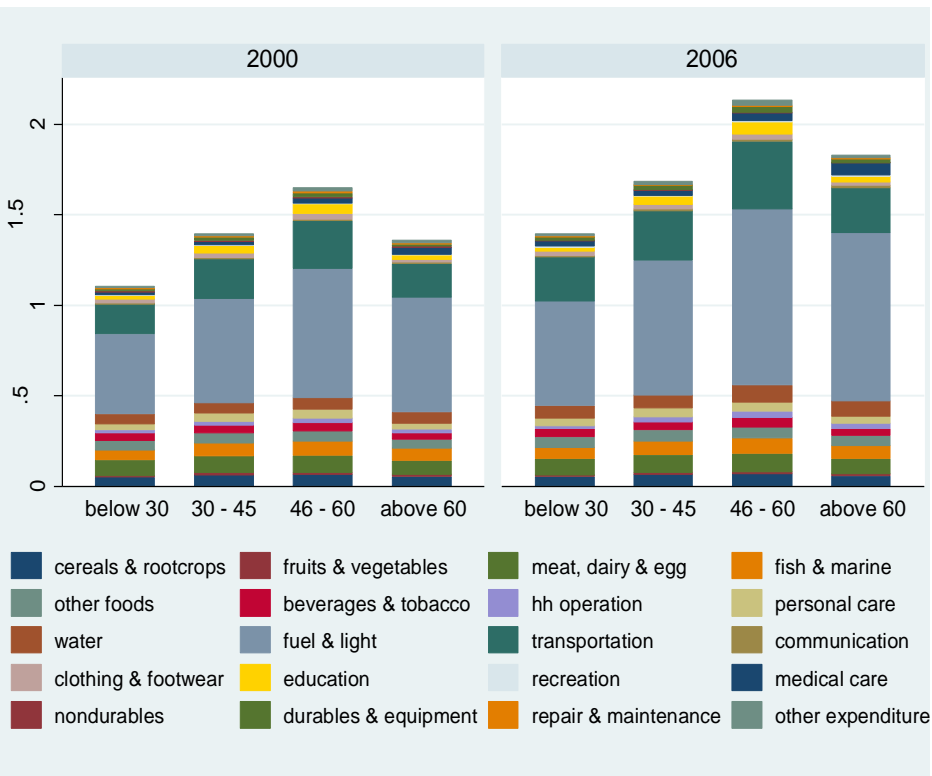


CO2 emmission by location

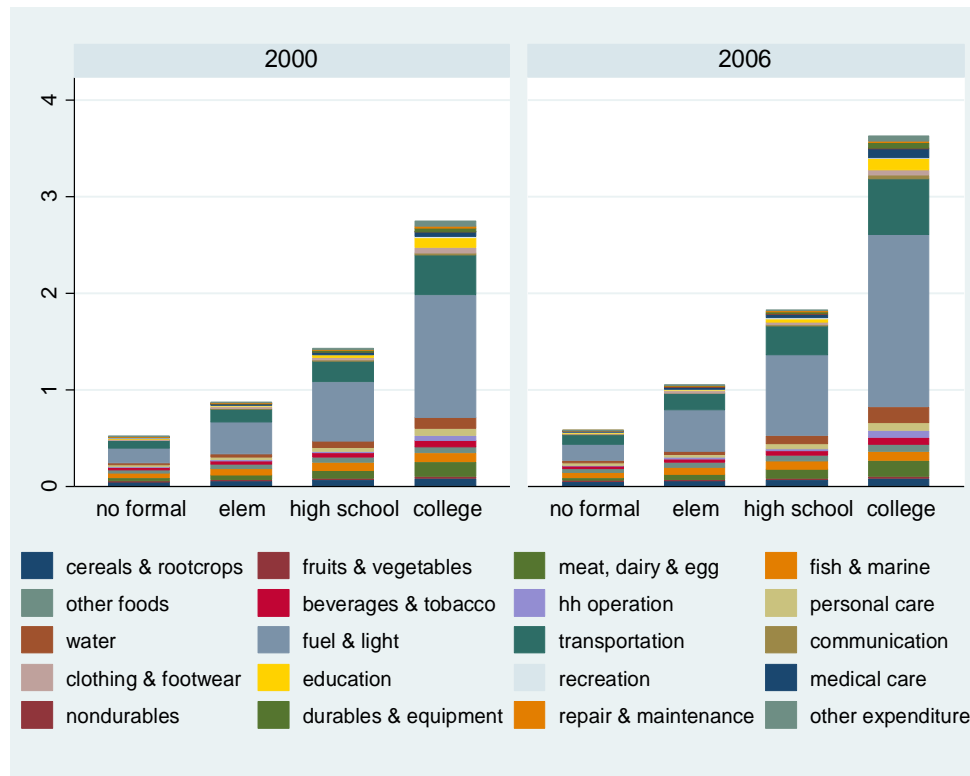
CO2 emmission by income quintiles



Characteristics of household CO₂ emission



CO2 emission by age category



CO2 emission by educational attainment



Factors affecting household carbon footprint

| Variables | Reg1 | | Reg2 | | Reg3 | | Reg4 | |
|------------------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
| | coef | se | coef | se | coef | se | coef | se |
| log expenditure | 1,051*** | 0,002 | 1,964*** | 0,037 | | | | |
| log exp_sq | | | -0,041*** | 0,002 | | | | |
| log income | | | | | 0,845*** | 0,003 | 1,618*** | 0,043 |
| log inc_sq | | | | | | | -0,035*** | 0,002 |
| age | 0,002*** | 0,001 | 0,003*** | 0,001 | 0,003*** | 0,001 | 0,004*** | 0,001 |
| age_sq | -0,000*** | 0,000 | -0,000*** | 0,000 | -0,000*** | 0,000 | -0,000*** | 0,000 |
| male | -0,047*** | 0,004 | -0,046*** | 0,004 | -0,054*** | 0,005 | -0,049*** | 0,005 |
| married | 0,055*** | 0,007 | 0,057*** | 0,007 | 0,065*** | 0,008 | 0,072*** | 0,008 |
| widow/separated | 0,033*** | 0,007 | 0,034*** | 0,007 | 0,026*** | 0,009 | 0,031*** | 0,009 |
| hh size | -0,003 | 0,002 | -0,006*** | 0,002 | 0,048*** | 0,002 | 0,049*** | 0,002 |
| hh size_sq | -0,001*** | 0,000 | -0,000 | 0,000 | -0,003*** | 0,000 | -0,003*** | 0,000 |
| elementary | 0,017*** | 0,006 | 0,016*** | 0,006 | 0,030*** | 0,007 | 0,016** | 0,007 |
| high school | 0,069*** | 0,006 | 0,065*** | 0,006 | 0,109*** | 0,007 | 0,089*** | 0,008 |
| at least college | 0,049*** | 0,007 | 0,079*** | 0,007 | 0,129*** | 0,008 | 0,154*** | 0,008 |
| urban | 0,132*** | 0,003 | 0,101*** | 0,003 | 0,175*** | 0,003 | 0,124*** | 0,003 |
| elec access | 0,490*** | 0,003 | 0,465*** | 0,003 | 0,542*** | 0,004 | 0,511*** | 0,004 |
| floor area | 0,006*** | 0,002 | 0,014*** | 0,002 | 0,037*** | 0,002 | 0,050*** | 0,002 |
| year 2006 | 0,073*** | 0,005 | 0,092*** | 0,005 | 0,183*** | 0,006 | 0,214*** | 0,006 |
| Region dummies | NO | | YES | | NO | | YES | |
| _cons | -12,57*** | 0,026 | -17,70*** | 0,213 | -10,82*** | 0,031 | -15,19*** | 0,247 |
| R-square | 0,9129 | | 0,9174 | | 0,8644 | | 0,8740 | |
| n | 76242 | | 76242 | | 76242 | | 76242 | |

note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$



Factors affecting household carbon footprint

| Variables | Reg5 | | Reg6 | | Reg7 | | Reg8§ | |
|------------------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
| | coef | se | coef | se | coef | se | coef | se |
| above poverty | 0,661*** | 0,004 | | | | | | |
| 2nd inc quint | | | 0,446*** | 0,005 | 0,729*** | 0,006 | | |
| 3rd inc quint | | | 0,765*** | 0,005 | 1,258*** | 0,006 | | |
| 4th inc quint | | | 1,129*** | 0,006 | 1,803*** | 0,006 | | |
| 5th inc quint | | | 1,668*** | 0,007 | 2,513*** | 0,006 | | |
| age | 0,016*** | 0,001 | 0,007*** | 0,001 | | | 0,025*** | 0,001 |
| age_sq | -0,000*** | 0,000 | -0,000*** | 0,000 | | | -0,000*** | 0,000 |
| male | -0,129*** | 0,008 | -0,056*** | 0,006 | | | -0,095*** | 0,008 |
| married | 0,110*** | 0,012 | 0,096*** | 0,010 | | | 0,009 | 0,013 |
| widow/separated | -0,035*** | 0,013 | 0,027** | 0,010 | | | -0,087*** | 0,014 |
| hh size | 0,264*** | 0,004 | 0,095*** | 0,003 | | | 0,163*** | 0,004 |
| hh size_sq | -0,012*** | 0,000 | -0,006*** | 0,000 | | | -0,007*** | 0,000 |
| elementary | 0,064*** | 0,010 | 0,061*** | 0,009 | | | 0,058*** | 0,011 |
| high school | 0,232*** | 0,011 | 0,144*** | 0,009 | | | 0,287*** | 0,011 |
| at least college | 0,620*** | 0,011 | 0,287*** | 0,010 | | | 0,731*** | 0,012 |
| urban | 0,275*** | 0,004 | 0,147*** | 0,004 | | | 0,251*** | 0,005 |
| elec access | 0,676*** | 0,005 | 0,564*** | 0,004 | | | 0,466*** | 0,006 |
| floor area | 0,210*** | 0,003 | 0,106*** | 0,002 | | | 0,234*** | 0,003 |
| year 2006 | 0,788*** | 0,008 | 0,386*** | 0,007 | | | 0,756*** | 0,009 |
| regional dummies | YES | | YES | | NO | | YES | |
| _cons | -4,226*** | 0,031 | -2,699*** | 0,027 | -1,240*** | 0,004 | -3,616*** | 0,033 |
| R-square | 0,748 | | 0,834 | | 0.7461 | | 0.5536 | |
| n | 76242 | | 76242 | | 76242 | | 76242 | |

note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

§ dependent variable is the residual from regression 7



But...

1. expenditure variable is endogenous because CO₂ emission was derived from the household expenditure.
*hh CO₂ emission = intensity * household expenditure*
2. although income variable is available, this is often unreliable in developing countries (Hentschel & Lanjouw, 1996). HH expenditures may provide better proxies for economic status (Deaton, 1992)
3. Aside from income and expenditure data, household's ownership of durable goods, equipment, housing quality are employed to capture household economic status

... use asset index



Which asset?

Household survey (Family Income & Expenditure, FIES)
data in Philippines includes different asset indicators

1. household ownership of consumer durables

- radio, tv, stereo, ref, wash machine, aircon, phone, oven, computer, sala & dining set, car, motorbike

2. characteristics of household dwellings

- House made of strong / light materials, flush toilet, pit/latrine or no toilet, sources of water

3. ownership of house and lot

- Owning house & lot, renting house & lot, not owning or renting house & lot



Classification of households by asset index

| Household Asset | Scoring Factors | Mean | Stdev | Index | Poorest 40% | Middle 40% | Richest 20% |
|--------------------------------|-----------------|-------|-------|--------|-------------|------------|-------------|
| ownership of radio | 0,088 | 0,662 | 0,473 | 0,187 | 0,548 | 0,714 | 0,789 |
| ownership of television | 0,274 | 0,638 | 0,481 | 0,569 | 0,218 | 0,880 | 0,996 |
| ownership of stereo | 0,221 | 0,245 | 0,430 | 0,514 | 0,034 | 0,243 | 0,672 |
| ownership of vtr/cd/dvd player | 0,271 | 0,337 | 0,473 | 0,573 | 0,029 | 0,372 | 0,887 |
| ownership of refrigerator | 0,299 | 0,383 | 0,486 | 0,614 | 0,022 | 0,451 | 0,970 |
| ownership of washing machine | 0,272 | 0,264 | 0,441 | 0,618 | 0,007 | 0,236 | 0,837 |
| ownership of aircon | 0,170 | 0,058 | 0,235 | 0,726 | 0,002 | 0,021 | 0,248 |
| ownership of sala set | 0,277 | 0,468 | 0,499 | 0,555 | 0,089 | 0,600 | 0,965 |
| ownership of dining set | 0,268 | 0,417 | 0,493 | 0,544 | 0,077 | 0,500 | 0,933 |
| ownership of car | 0,177 | 0,061 | 0,238 | 0,744 | 0,001 | 0,014 | 0,273 |
| ownership of phone | 0,248 | 0,326 | 0,469 | 0,529 | 0,054 | 0,346 | 0,833 |
| ownership of oven | 0,173 | 0,050 | 0,219 | 0,789 | 0,000 | 0,008 | 0,237 |
| ownership of computer | 0,166 | 0,043 | 0,204 | 0,815 | 0,000 | 0,005 | 0,207 |
| ownership of motorbike | 0,118 | 0,084 | 0,277 | 0,426 | 0,010 | 0,086 | 0,227 |
| House made of strong materials | 0,206 | 0,698 | 0,459 | 0,449 | 0,424 | 0,833 | 0,978 |
| House made of light materials | -0,244 | 0,451 | 0,498 | -0,491 | 0,797 | 0,304 | 0,050 |
| Have a flush toilet | 0,238 | 0,730 | 0,444 | 0,535 | 0,406 | 0,924 | 0,990 |
| Have a pit/latrine toilet | -0,161 | 0,165 | 0,371 | -0,433 | 0,352 | 0,056 | 0,008 |
| Have no toilet | -0,150 | 0,105 | 0,307 | -0,488 | 0,242 | 0,019 | 0,001 |
| Water from water system | 0,191 | 0,442 | 0,497 | 0,384 | 0,200 | 0,509 | 0,794 |
| Water from well/pump | -0,133 | 0,454 | 0,498 | -0,267 | 0,614 | 0,427 | 0,185 |
| Water from river,rain,etc. | -0,094 | 0,104 | 0,306 | -0,307 | 0,186 | 0,064 | 0,021 |
| Owning house and lot | 0,073 | 0,704 | 0,456 | 0,160 | 0,625 | 0,724 | 0,823 |
| Renting house and lot | 0,055 | 0,058 | 0,233 | 0,236 | 0,019 | 0,077 | 0,098 |
| Not owning/renting house & lot | -0,108 | 0,238 | 0,426 | -0,254 | 0,356 | 0,200 | 0,078 |



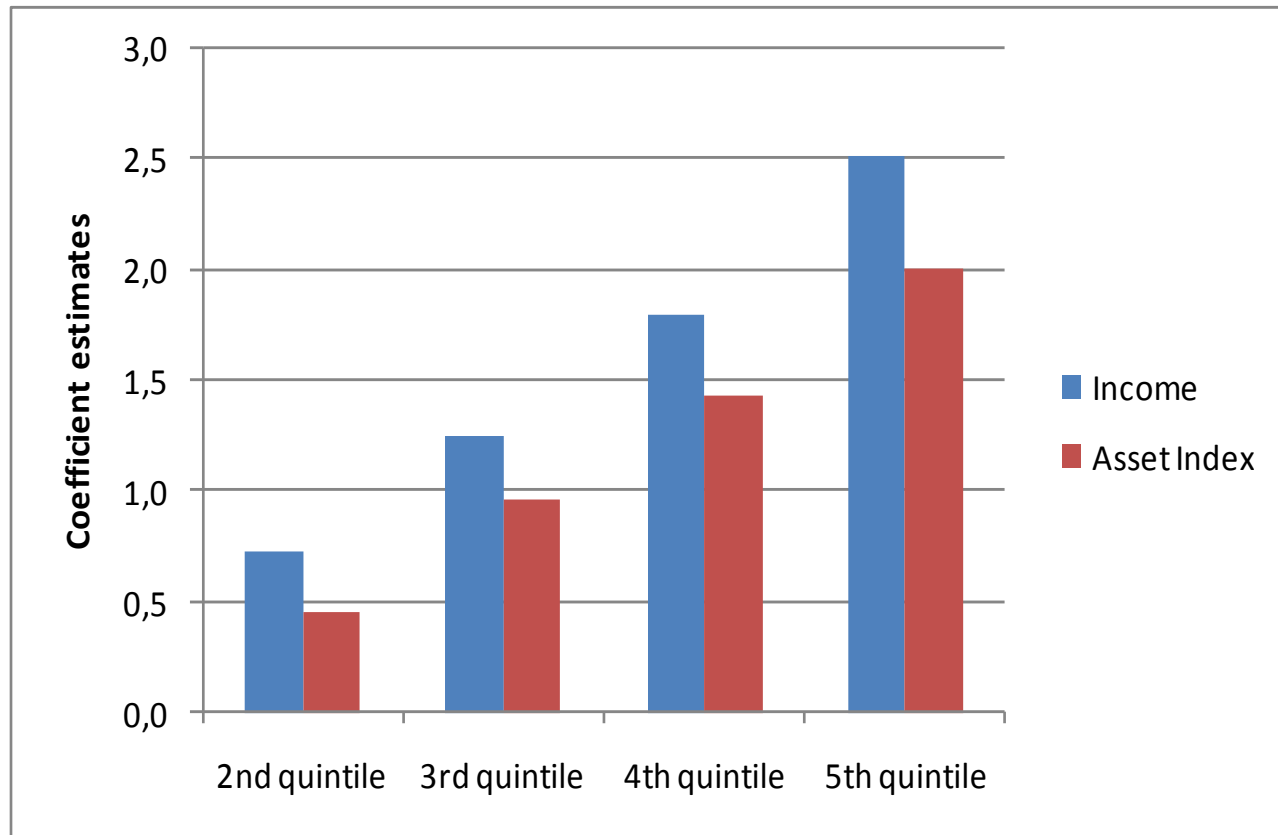
Determinants of household carbon emission

| Variables | Reg9 | | Reg10 | | Reg11 | | Reg12§ | |
|--------------------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
| | coef | se | coef | se | coef | se | coef | se |
| asset index | 0,135*** | 0,001 | | | | | | |
| 2nd assetind quint | | | 0,088*** | 0,006 | 0,454*** | 0,008 | | |
| 3rd assetind quint | | | 0,273*** | 0,007 | 0,964*** | 0,008 | | |
| 4th assetind quint | | | 0,538*** | 0,008 | 1,437*** | 0,008 | | |
| 5th assetind quint | | | 0,857*** | 0,009 | 2,010*** | 0,008 | | |
| age | 0,018*** | 0,001 | 0,018*** | 0,001 | | | 0,013*** | 0,001 |
| age_sq | -0,000*** | 0,000 | -0,000*** | 0,000 | | | -0,000*** | 0,000 |
| male | -0,072*** | 0,007 | -0,075*** | 0,007 | | | -0,100*** | 0,007 |
| married | 0,071*** | 0,012 | 0,076*** | 0,012 | | | 0,051*** | 0,011 |
| widow/separated | -0,015 | 0,013 | -0,015 | 0,013 | | | -0,041*** | 0,012 |
| hh size | 0,182*** | 0,004 | 0,184*** | 0,004 | | | 0,034*** | 0,003 |
| hh size_sq | -0,008*** | 0,000 | -0,009*** | 0,000 | | | -0,003*** | 0,000 |
| elementary | 0,072*** | 0,011 | 0,083*** | 0,011 | | | 0,057*** | 0,009 |
| high school | 0,230*** | 0,011 | 0,247*** | 0,011 | | | 0,220*** | 0,010 |
| at least college | 0,521*** | 0,012 | 0,552*** | 0,012 | | | 0,502*** | 0,010 |
| urban | 0,214*** | 0,004 | 0,224*** | 0,004 | | | 0,195*** | 0,005 |
| elec access | 0,652*** | 0,006 | 0,694*** | 0,006 | | | 0,471*** | 0,005 |
| floor area | 0,169*** | 0,003 | 0,182*** | 0,003 | | | 0,176*** | 0,003 |
| year 2006 | 0,607*** | 0,008 | 0,646*** | 0,008 | | | 0,531*** | 0,008 |
| regional dummies | YES | | YES | | NO | | YES | |
| _cons | -3,163*** | 0,033 | -3,680*** | 0,032 | -0,950*** | 0,006 | -2,197*** | 0,029 |
| R-square | 0,7494 | | 0,7435 | | 0,5024 | | 0,4731 | |
| n | 76242 | | 76242 | | 76242 | | 76242 | |

note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ §dependent variable is the residual from regression 11



Comparison of estimates




Regression coefficients using income and asset index



Concluding remarks

- Income and asset index is consistent with its effect on household carbon footprint
 - ✓ there is a significant nonlinear relationship between emission and income
 - ✓ rich households are leading a carbon intensive lifestyle compared to poor households
 - ✓ fuel, light & water and transportation are the two most CO₂ intensive emitting household consumption category
- Other household characteristics significantly affects carbon footprint. Urbanity, married status, access to elec, floor area and highly educated household heads emits more CO₂ while males tend to have lower carbon footprint. Age and household size has a nonlinear effect on household carbon footprint
- **FURTHER WORK**
 - ✓ Decomposition of emission and analysis of hh emission inequality





Thank you for your attention