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Energy consumption, aging population and consumption habits

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Outline

- Residential energy demand and aging population
- Key drivers
- Stylized facts for Italian households
- Empirical analysis: pooled regression and cohort decomposition
- Concluding remarks

Research question

Are there cultural factors interplaying with aging in shaping household energy use?

Do generations matter in energy consumption behaviour?

Residential energy use drivers and aging population

Energy choices can be better understood by looking at the interactions between **cognitive norms**, (e.g. beliefs, understandings), **material culture** (e.g. technologies, building form) and **energy practices** (e.g. activities, processes) (Stephenson et al., 2010).

Energy culture standards are not immutable. On the contrary new standards can be rapidly adopted and they can be shaped by prevalent behaviours among society as well as by technology availability.

Therefore household energy demand is a combination of **external** structural characteristics (dwellings, whether, technology level) and **human** characteristics (socio-demographic, psychological and cultural elements).

Main drivers of residential energy demand and impact of aging

		General effect	Aging pop. Effect
Non- Human factors	**Dwelling**	↑Size & age of Dwelling →↑ ener. Exp.;	Bigger and Older dwellings
	Technology	↑ en. saving investm.↓ energy ; Costas et al. (2011) found link between energ. efficiency and energy prices → consum. bias	Less investment expected; however, in Italy elderly increase energy-saving investments
	Weather	↑ temp. ↓gas & ↑electr	Migration of elderly; US case
Human factors	**Family size**	↑ family size ↑ tot consumpt, & ↓ per capita cons.→ higher economies of scale	Smaller family size: ↓economy of scales
	Education	Higher educ. ↓ ene. cons., higher edu. ↑ en. saving investment	Are younger generations more educated?
	Income	↑ income ↑ energy, higher room for investment	No clear effect. Usually elderly have less income and more accumulated wealth; however, in Italy they coped better with the financial crisis
	Culture	↑ Env. Attitude ↓ Energy Consumpt.; Air conditioning and electronic devices now perceived as "basic goods"	Less env. friendly (Torgler et al. 2008); less energy-saving attitude (war generations disappear, Carlsson-Kanyama et al. (2005)), "new elderly" more "tecnology addicted"

Is population structure harming further energy efficiency improvements?

Population ageing is a long-term trend which began several decades ago in Europe. In Italy the proportion of population aged 65 and over (21% in 2014) is the highest among European countries.

Economic literature almost universally predicts that aging population leads to an aggregate increase in energy consumption demand: older households spend more on energy, especially on heating, because they occupy houses for a larger proportion of the day.

This means that public policies aimed at reaching higher energy efficiency in Italy can be less effective.

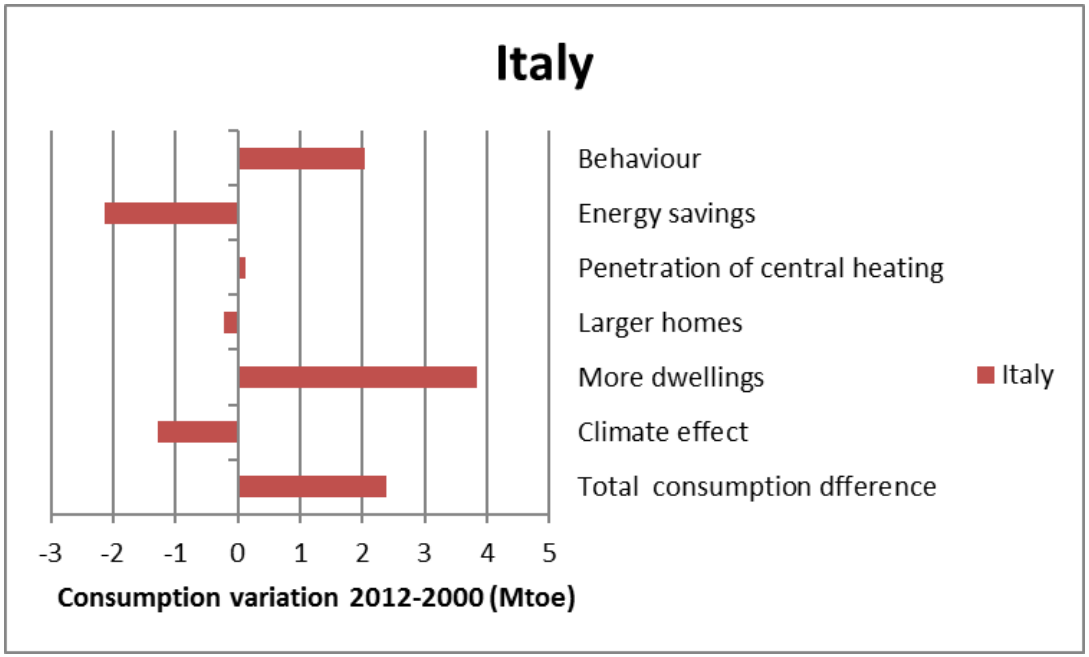
Some stylized facts

An increase in heating expenditure during last decades essentially due to expanded stock of dwellings and to changes in consumer behaviour.

EU exhibits the opposite trend.

During the same period electricity use also increased more than EU average.

Contribution to changes in residential space heating



Cross sectional evidence for Italian households (1)

Data: Italian Household Expenditure Survey (1997-2013, ISTAT) about household energy consumption and socio-demographic characteristics (sex, age, education, family size, dwelling characteristics…).
Sample size: more than 20.000 households every year

	1997			2013		
Age classes	Weighted Freq.	Weighted Freq.	Househ. Size (mean)	Weighted Freq.	Weighted Freq.	Househ. Size (mean)
18-24	143,888	0.7%	2.0	78,734	0.3%	1.7
25-29	849,854	4.0%	2.2	506,697	2.0%	1.9
30-34	1,610,475	7.5%	2.7	1,166,908	4.6%	2.3
35-39	2,040,572	9.5%	3.2	2,040,740	8.0%	2.6
40-44	2,050,547	9.6%	3.3	2,459,280	9.6%	2.9
45-49	2,166,883	10.1%	3.4	2,835,754	11.1%	2.9
50-54	1,972,227	9.2%	3.3	2,743,916	10.8%	2.9
55-59	2,069,242	9.6%	2.9	2,468,415	9.7%	2.7
60-64	1,958,594	9.1%	2.5	2,153,662	8.4%	2.3
65-69	1,959,762	9.1%	2.1	2,169,403	8.5%	2.1
70-74	1,923,905	9.0%	1.8	2,084,170	8.2%	1.8
>75	2,712,880	12.6%	1.7	4,788,616	18.8%	1.6
Total	21,458,829	100.0%	2.7	25,496,295	100.0%	2.3

- ✓ Increased share of older hh
- ✓ increased household numbers
- ✓ decrease in average family size

Cross sectional evidence for Italian households (2)

The share of residential energy expenditure over total consumption expenditure has increased (5.7% in 1997 - 6.3% in 2013).
This share is linearly increasing with age classes: elderly people need more thermal comfort and spend more on heating.

Residential energy expenditure by householder age classes

Age classes	Resid. Energy share over total consumpt.		Households with Energy consumption share >10%		Per capita heating nominal expenditure		Per capita electricity nominal expenditure	
	1997	2013	1997	2013	1997	2013	1997	2013
18-24	5.2%	4.9%	14.6%	9.6%	355	405	169	331
25-29	4.3%	5.3%	7.3%	8.9%	288	449	146	320
30-34	4.9%	5.5%	9.4%	11.9%	327	472	135	293
35-39	4.9%	5.5%	8.5%	11.0%	270	426	134	259
40-44	4.9%	5.6%	8.4%	10.4%	269	409	137	249
45-49	5.2%	5.8%	10.8%	12.5%	286	449	150	248
50-54	5.1%	5.8%	9.2%	11.2%	307	482	154	261
55-59	5.5%	6.1%	11.3%	14.1%	356	508	154	290
60-64	5.9%	6.2%	14.4%	15.9%	388	560	169	304
65-69	6.2%	6.5%	14.9%	15.8%	393	643	172	308
70-74	6.8%	6.8%	18.1%	19.4%	429	667	173	322
>75	7.4%	7.6%	23.9%	24.1%	471	754	173	327
Total	5.7%	6.3%	13.0%	15.4%	350	554	155	289

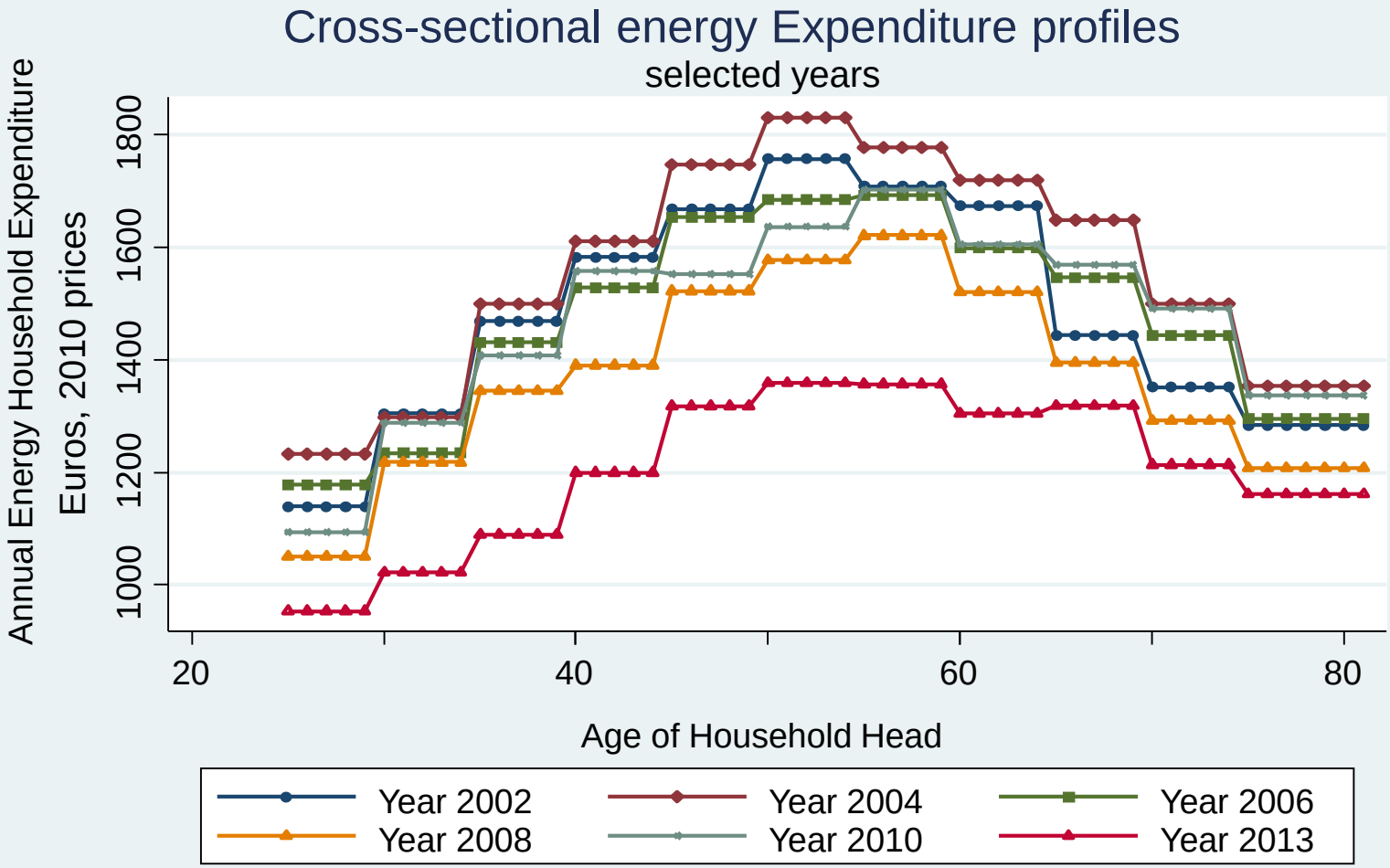
Pooled regression: demographic and structural drivers of energy demand

Equivalent energy expenditure rises with:

- age, non linearly
- Feminine gender
- Lower education level
- Lower hh size
- Total equivalent consumption (proxy of income)
- Dwelling age

Age coefficient magnitude is triple for heating wrt electricity

	Energy	Electricity	Heating
Age classes	0.054***	0.098***	0.017***
	(0.005)	*(0.007)*	*(0.004)*
Age square	-0.001***	-0.004***	0.000*
	(0.000)	*(0.000)*	*(0.000)*
Gender	0.035***	0.011***	0.050***
	(0.004)	*(0.003)*	*(0.006)*
Education level	-0.033***	-0.022**	-0.072***
	(0.009)	*(0.008)*	*(0.009)*
Employment status	-0.005	-0.044***	0.033***
	(0.006)	*(0.004)*	*(0.009)*
Total equivalent consumpt. (ln)	0.423***	0.196***	0.427***
	(0.006)	*(0.004)*	*(0.008)*
North	0.203***	-0.214***	0.563***
	(0.009)	*(0.011)*	*(0.017)*
Center	0.124***	-0.085***	0.374***
	(0.010)	*(0.008)*	*(0.017)*
Property	-0.022***	-0.045***	-0.008**
	(0.004)	*(0.004)*	*(0.004)*
Room number	0.066***	0.058***	0.077***
	(0.002)	*(0.002)*	*(0.003)*
Houlsehold size	-0.038***	-0.028***	-0.067***
	(0.002)	*(0.004)*	*(0.002)*
Air conditioning	0.032***	0.191***	
	(0.005)	*(0.013)*	
Non ordinary maintenance	-0.012*	-0.047***	-0.009
	(0.006)	*(0.006)*	*(0.011)*
Dwell. age: 1910-1950	0.003	0.001	-0.016
	(0.011)	*(0.009)*	*(0.013)*
Dwell. age: 1950-1980	-0.010	-0.004	-0.033**
	(0.009)	*(0.009)*	*(0.014)*
Dwell. age: Post 1980	-0.022**	0.004	-0.010
	(0.009)	*(0.009)*	*(0.014)*
Dwelling type	0.092***	0.106***	0.109***
	(0.004)	*(0.004)*	*(0.009)*
Heating types	0.021***		0.072***
	(0.006)		*(0.011)*
Fixture invest.			-0.012
			(0.028)
Constant	1.796***	3.123***	1.049***
	(0.067)	*(0.078)*	*(0.090)*
R^2	0.18	0.11	0.17
N	362,871	383,066	339,809



Each cross sectional profile shows the different generations at different ages in one point in time.

Age effects and cohort effects

To identify whether “energy culture” changes over time we need to distinguish between **age** (life-cycle) and **cohort** (generational) effects in consumption profiles.

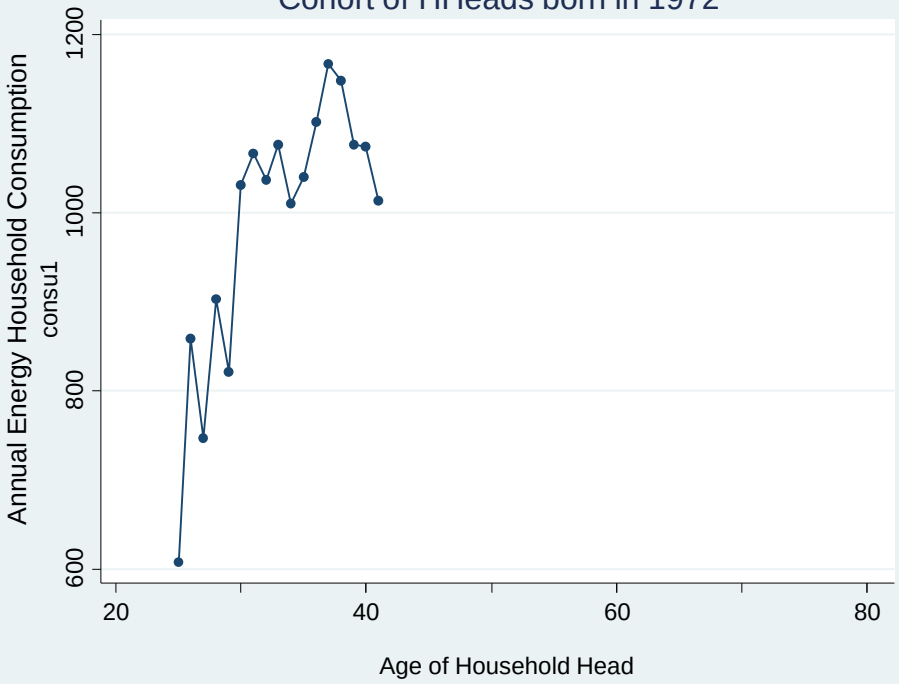
Cohorts are built by date of birth of the household head, in 1997 (first year of our dataset). For each survey, we average the expenditure by age of head and then track the sample from the same cohort one year older in the next survey.

We limit our attention to hh heads aged between 25 - 65 (aged 41-81 at the end of the period) with a total of 73 cohorts.

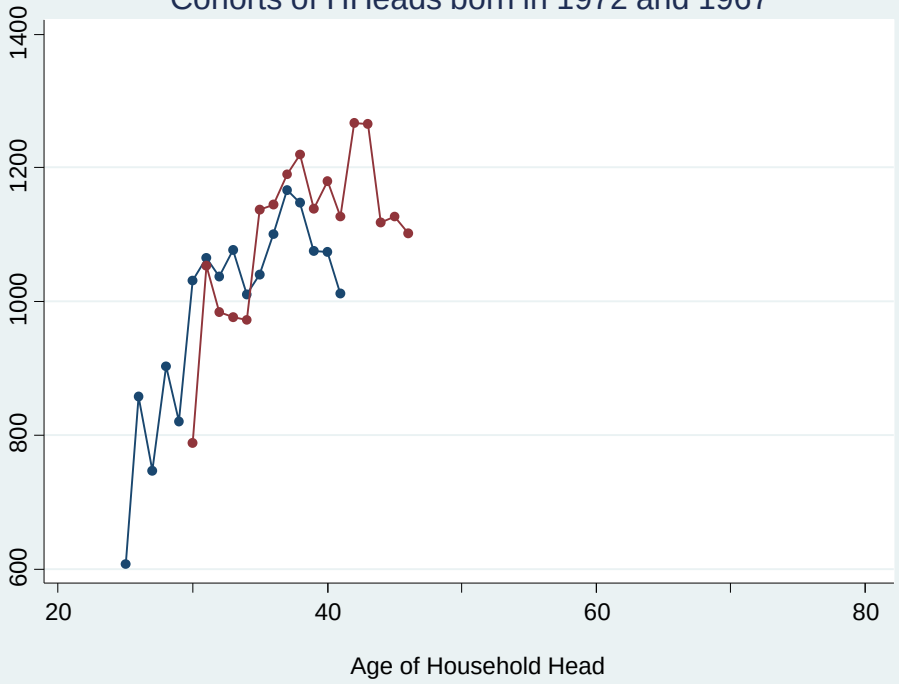
Age and Cohort: energy consumption

How do different generations behave?

Cohort of HHeads born in 1972



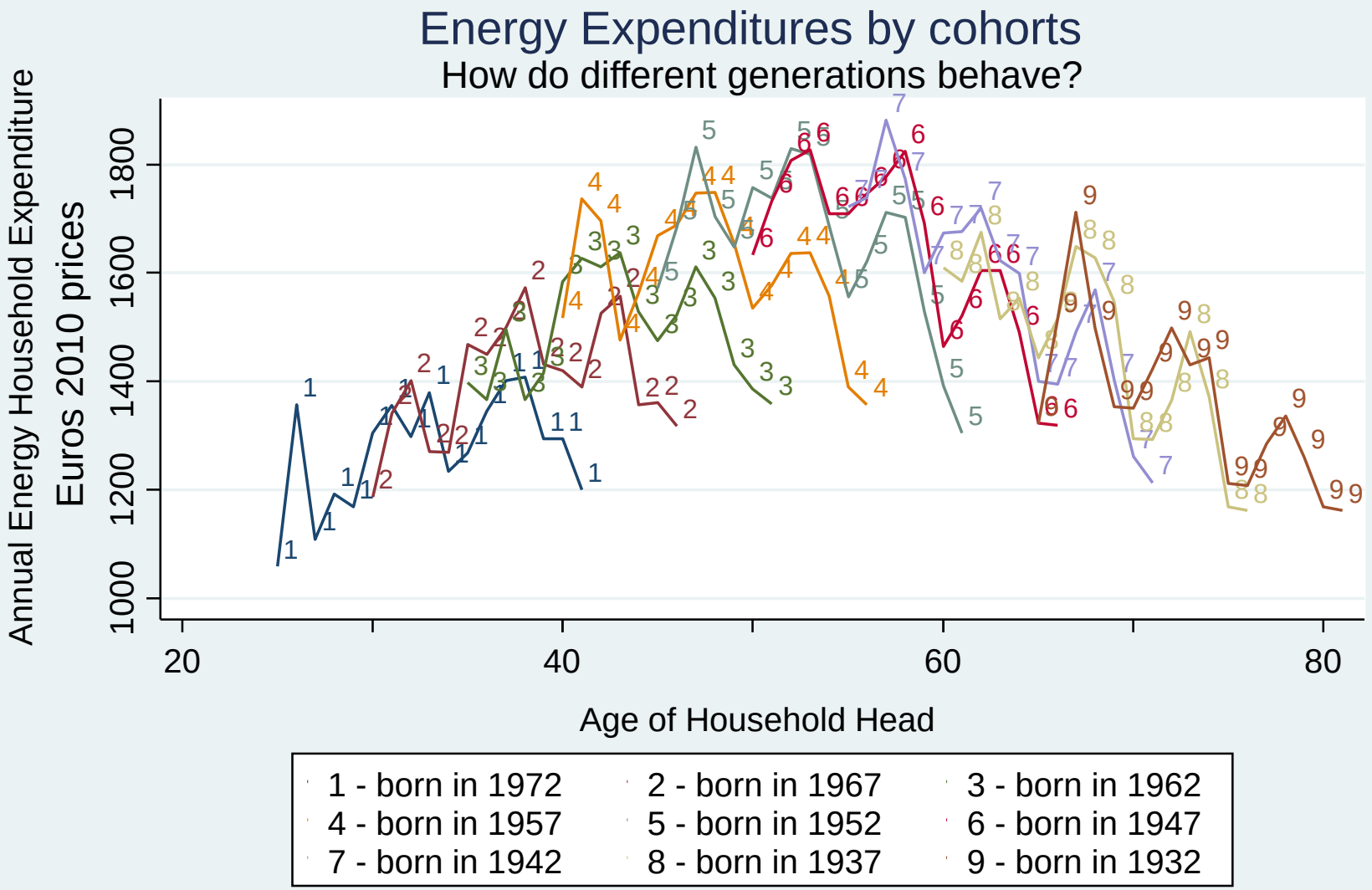
Cohorts of HHeads born in 1972 and 1967



5 **Selected Cohorts Definition and Average Consumption**

Cohort	Year of Birth	Age of Cohort in 1997	Age of Cohort in 2013	Cell Size in 1997	Energy Consumption in 1997
1	1972	25	41	69	1,158
2	1967	30	46	240	1,299
3	1962	35	51	472	1,544
4	1957	40	56	478	1,632
5	1952	45	61	471	1,764
6	1947	50	66	508	1,832
7	1942	55	71	433	1,959
8	1937	60	76	411	1,822
9	1932	65	81	383	1,534

Note: (Annual) expenditure is expressed in euros


Energy Expenditures by cohorts
How do different generations behave?
Annual Energy Household Expenditure
Euros 2010 prices
1000
1200
1400
1600
1800
20
40
60
80
Age of Household Head
1 - born in 1972
2 - born in 1967
3 - born in 1962
4 - born in 1957
5 - born in 1952
6 - born in 1947
7 - born in 1942
8 - born in 1937
9 - born in 1932

Age, cohort and time effects

We decompose the three sets of effects according to this model (Deaton and Paxson, 1994):

$$y = \beta + A\alpha + C\gamma + T\psi + u$$

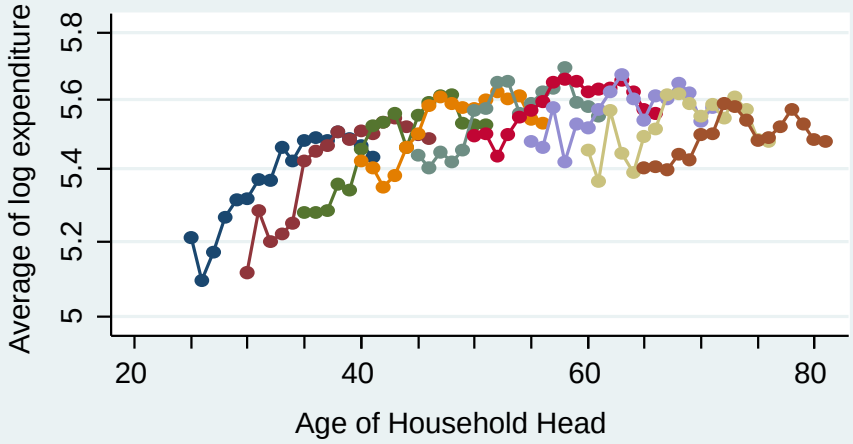
where y is the energy consumption, A is a matrix of age dummies, C a matrix of cohort dummies, and T a matrix of year dummies.

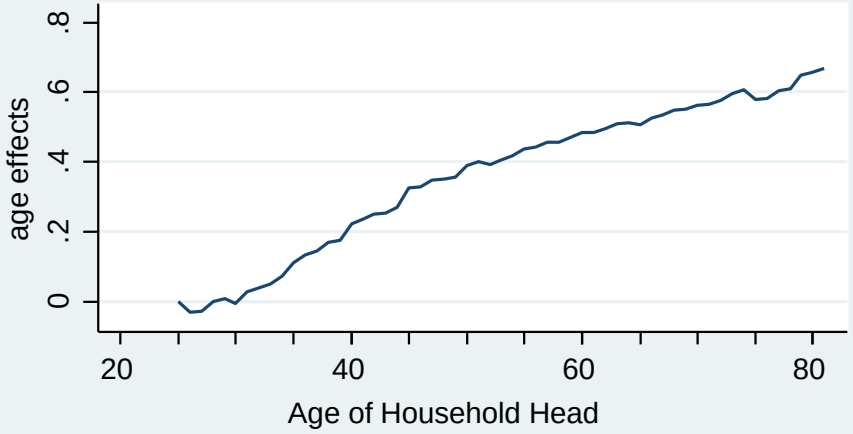
We must drop one column from each of the three matrices of dummies, to avoid singularity.

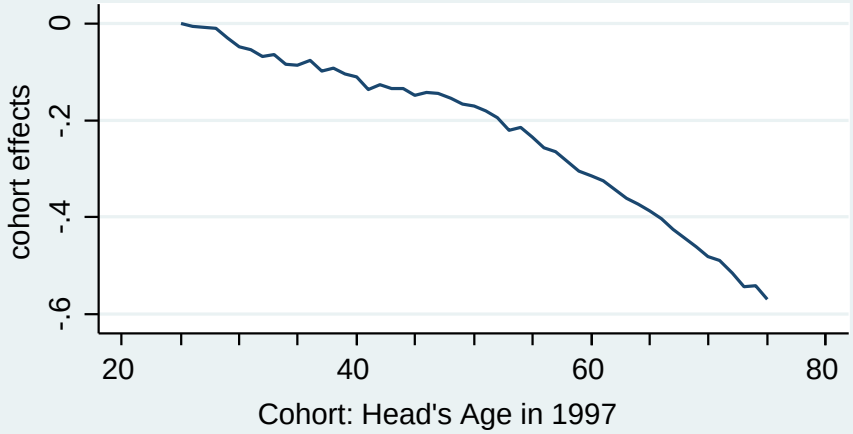
Moreover, it is still impossible to estimate this regression because of an additional linear relationship across age, cohort and year (age is the sum of cohort and time).
One of the most common solution is to impose the constraint that year dummies coefficients are orthogonal to a time-trend and sum to zero (Deaton and Paxson, 1994.) This means that time in itself does not have a persistent effect but it gives exogenous shocks which sum to zero in the long run.

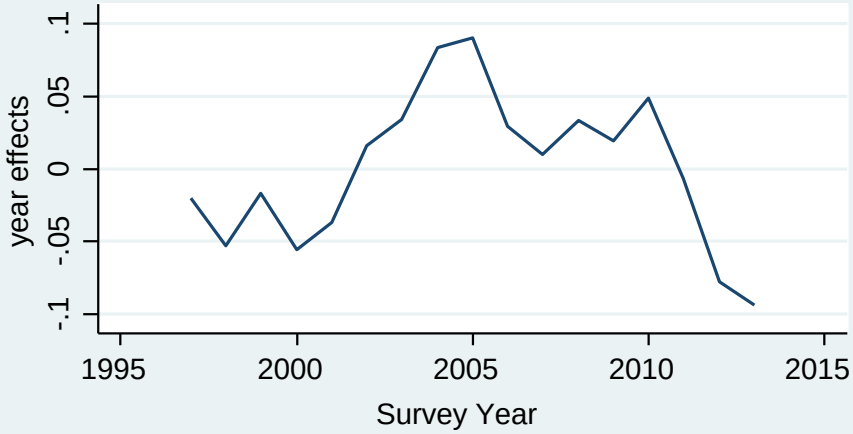
Electricity

equivalent expenditure







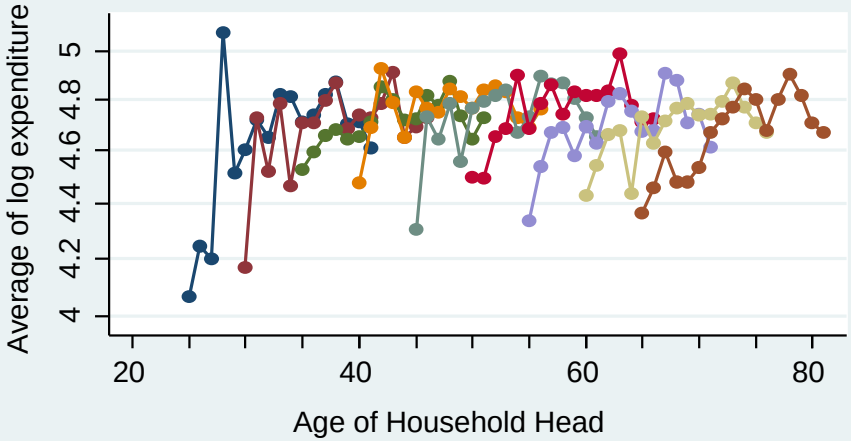


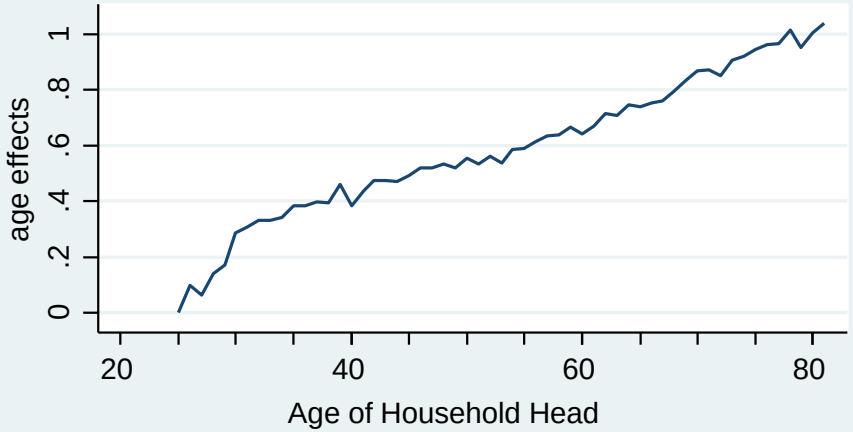
Electricity: age and cohort effects

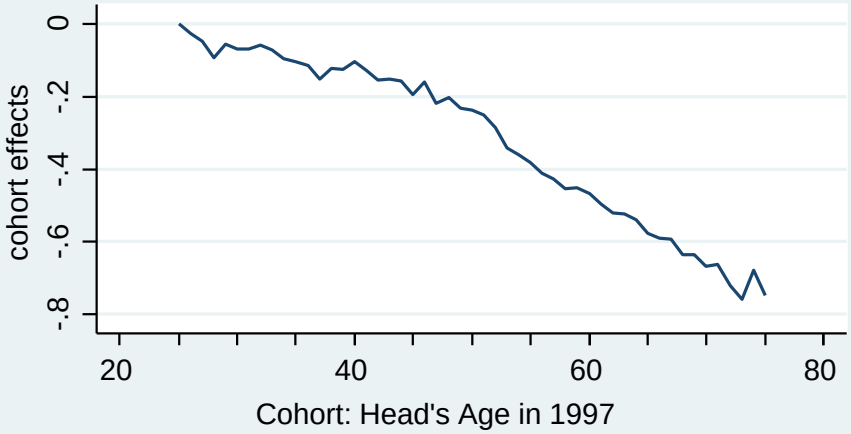
- All the effects are jointly statistically significant
- Equivalent electricity expenditure rises with age, with a peak around the age of 55 and then flattening out at older ages. The age effect parameter rises from zero to 0.4 between ages 25 and 50 and then increases to 0.65 at age 80.
- The cohort effects steadily decline from younger to older generations: the expenditure at age 50 of someone born in 1963 is on average 20 per cent higher than the expenditure at the same age of someone born in 1947.

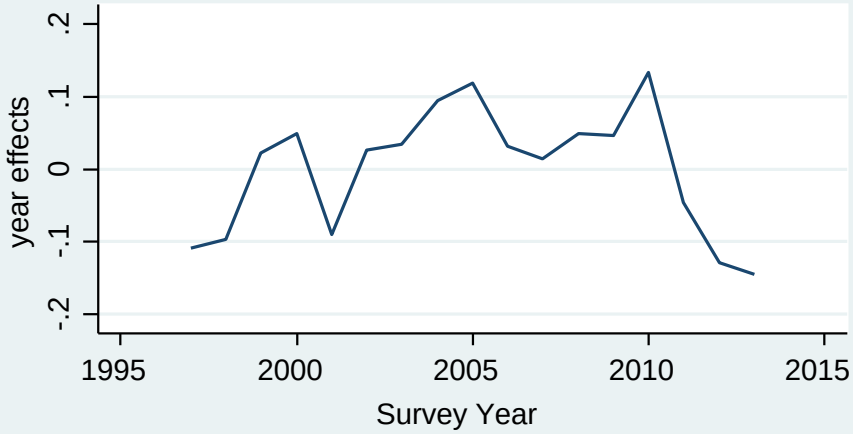
Heating Fuels

equivalent expenditure









Heating fuels: age and cohort effects

- Equivalent heating expenditure rises with age, and the effect is steeper before the age of forty. The magnitude is larger than in the case of electricity.

- The cohort effects and they steadily decline from younger to older generations: hh heads born in the 1970s have significantly increased their consumption

In general

We may roughly divide the 73 cohorts into two groups: the younger generations born between 1947 and 1988 (post-war) and the older generations born between 1916 and 1946 (pre-war and war).

- ✓ For the younger generations, the cohort effect coefficients are between 0 and -0.2 for both energy categories, with no large inter-cohort difference in the pattern of spending. The younger cohort grew up in the post-war period, a time of relative peace and economic growth.

- ✓ For the older generation, the cohort effects clearly show that cohorts born earlier spend less while those born later spend more. Most of these cohorts lived through the war and their spending attitudes were influenced by the experience.

Conclusions

The decomposition shows the importance of age and cohort effects, confirming that recent generations have a higher residential energy expenditure with respect to the oldest cohort observed (war generations disappear).

The energy culture of Italian new generations seems more linked to thermal comfort (heating and air conditioning) than to environmental attitude and so aging population means smaller family size, more residential energy demand and more effort needed to increase energy efficiency.

Future residential energy consumption will result from a combination of an age and a cohort effect. The cohort effect is expected to strengthen the age effect.

However, this picture can change if future income growth and distribution among generations are taken into account because more income uncertainty will probably characterize the aging society.

Thank you for your attention

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