A case using EU SILC microdata

Determinants of household energy expenditures in Austria

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Introduction

Study Background

Previous Studies

Research Objectives

Study Background

- A sizable proportion of household budget is allocated toward direct consumption of energy
- Well-known that building characteristics play a large role in how much households spend on energy
- Recent research shows that socio-economic factors also play a significant role in determining household energy consumption patterns
- Principal-agent problems (e.g. asymmetric information, split incentives) in the landlord-tenant relationship may play a role in the level of energy efficiency of a dwelling

Research Objectives

- Three main research questions:
  1. What are the determining factors of household energy expenditure in Austria?
  2. What are the regional differences in these factors?
  3. What are the differences in these factors between different types of households?

- Empirical analysis using a conditional-demand approach

- Based on household-level micro-data from the 2012 EU SILC in Austria

- Case study for EU SILC data in residential energy-related research

Previous Studies

- Verhallen and van Raaij (1981) were one of the first to use household survey data to investigate determinants of household energy use
- Discrete-continuous modelling framework:
  - Dubin and McFadden 1984; Bernard et al. 1996; Lee and Singh 1994; Schuler et al. 2000; Nesbekken 2001; Liao and Chang 2002; Brounen et al. 2012
  - Braun 2010 used a discrete-choice analysis on extensive socio-economic factors
- Conditional-demand modelling framework (like this analysis):
  - Previous studies employ similar approaches but differ in sets of demographic or other socio-economic characteristics used to explain residential energy demand
  - Gorbacz (1983); Green (1987); Baker et al. (1989); Branch (1993); Leth-Petersen and Togeby (2001)
- Of particular interest to the current analysis:
  - Rehdanz (2007) for Germany
  - Meier and Rehdanz (2010) for Great Britain

Data & Model Specification

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EU SILC Dataset

Sample Design

Model Specification

EU Statistics on Income and Living Conditions (SILC) Dataset

- Cross-sectional and longitudinal, multidimensional micro-data
- Variables on housing, demographics, socio-economic and financial characteristics on individual and household levels
- Nationally representative dataset with around 6,000 households participating annually (Statistik Austria, 2014)
- Typically used to investigate social inclusion, housing cost burden, living conditions, and other similar socio-economic issues (e.g. Deidda, 2015)
- Energy-related research questions using SILC microdata focus mainly on energy poverty (cf. Papada and Kaliampakos, 2016; Tirado and Jiménez Meneses, 2016)

EU Statistics on Income and Living Conditions (SILC) Dataset

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- Schaffrin and Reibling (2015) were one of the first to employ SILC to analyse energy consumption practices at the household level in Denmark, Austria and the United Kingdom
  - Analysis was limited to estimating total utility costs as a portion of total housing costs due to limitations in the data at that time (2005/2008)

- 2012 survey year included an *ad hoc* module that collected information on housing conditions

- Additional variables included:
  - Energy fuel sources
  - Heating system
  - Presence/absence of renewable energy
  - Annual energy expenditures per fuel
  - Condition of dwelling

Sample Design

- Households excluded from the sample design include those:
  - Receiving social benefits, living rent free, or paying a reduced rent
  - In social housing, student housing, hospitals or nursing homes
  - Reporting less than 100€ in energy costs for 2012
  - Less than one year of occupancy in the dwelling (i.e. moved in after 2011)
  - Reporting income from rental property
  - Without water connections

- Final sample size: 4,164 households (66% owners, 34% renters)
  - Owners include both house and apartment owners
  - Renters include main renters, subtenants, and co-operative tenants (*Genossenschaftswohnungen*)

Model Specification

Variable group	Variable	Definition
Dependent	L_EXP_SM	Log of annual expenditure for energy per square meter
Tenure	OWNER	Unity if owner-occupied, zero otherwise
Building characteristics	TYPE	Type of building (e.g. detached, semi-detached, multifamily house, etc.)
	VINTAGE	Period of construction (e.g. before 1919, 1919-1944, 1945-1971, etc.)
	L_SIZE	Log of dwelling size in square meters
	BATH	Unity if dwelling has bath or shower, zero otherwise
	PROBLEM	Unity if dwelling has structural problems (i.e. rot, moisture), zero otherwise
Heating and fuel characteristics	HEAT_C	Unity if dwelling has central heating system (i.e. district heating, electric heating), zero otherwise
	FUEL	Type of fuel source: Gas, oil, wood, coal or none (i.e. electricity only); fuels are *not* mutually exclusive, fuel stacking allowed in model
	RENEW	Unity if dwelling is using any form of renewable energy, zero otherwise
Socio-economic characteristics	NOTPAID	Unity if household does not pay for one or more of the fuels, zero otherwise
	L_INCOME	Log of household disposable income in euros
	ADULTS	Number of adults older than 16 in household
	CHILDREN	Number of children 16 or under in household
	L_AGE	Log of age of the oldest household member
	UNEMPL, PENSION	Number of officially registered unemployed and retired persons in household, respectively
Regional characteristics	STATE	Austrian Federal State where the dwelling is located
	URBAN	Level of urbanization: Densely populated, intermediate, thinly populated; unity or zero

Model Specification

- 7 log-linear models are estimated using OLS
- Sample sizes are healthy for each specification, i.e. above 800 observations

	Model	Sample design	Sample size
1	Austria-wide	Includes all households that meet the sampling criteria	4164
2	Vienna	Restricted to Vienna only	832
3	Eastern	Burgenland, Lower Austria (excl. Vienna)	965
4	Western	Upper Austria, Salzburg, Tyrol, Vorarlberg	1519
5	Southern	Carinthia, Styria	848
6	Owners	Owner-only sample	2745
7	Renters	Renter-only sample	1419

Empirical Results

Descriptive Statistics

Determinants of Energy Expenditures

Differences in Determinants: Regional

Differences in Determinants: Tenure

Descriptive Statistics

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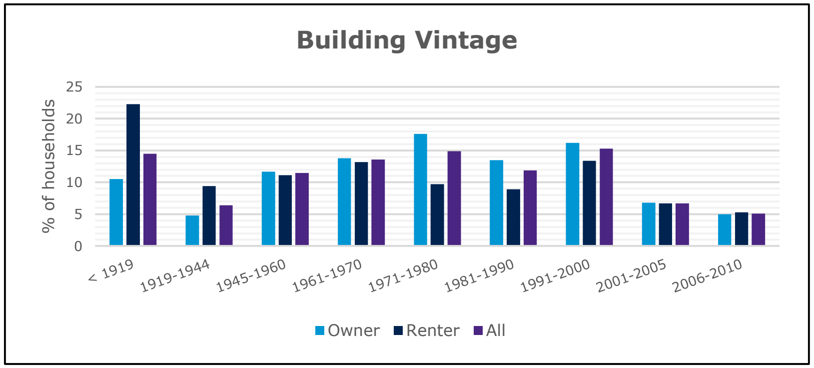

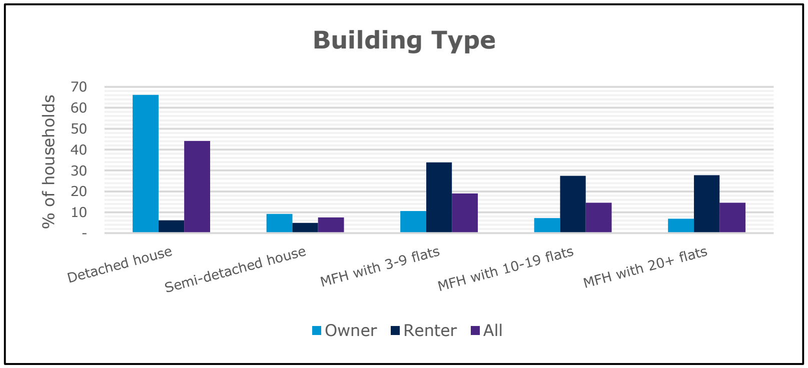

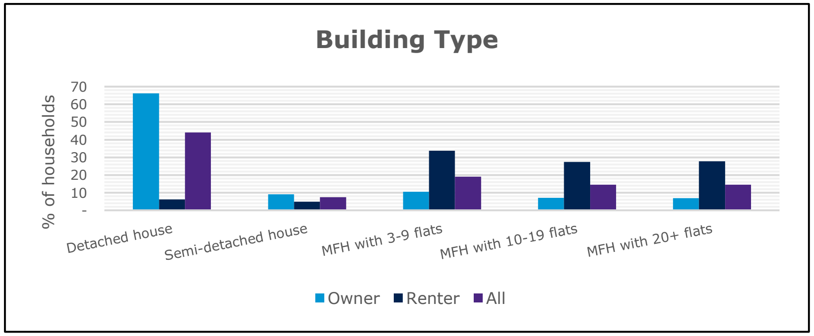

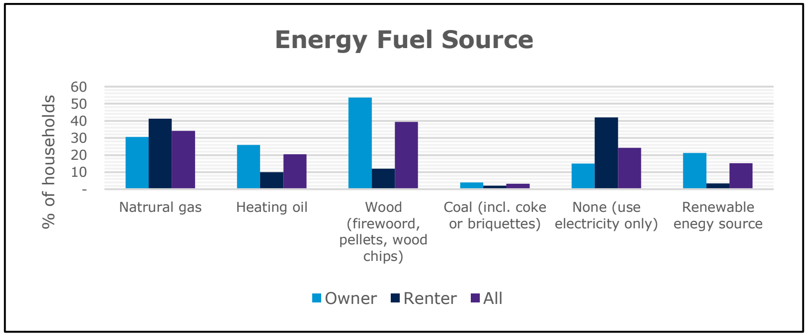

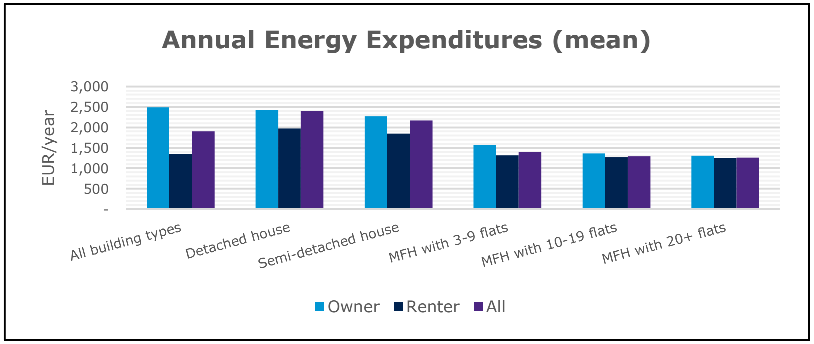

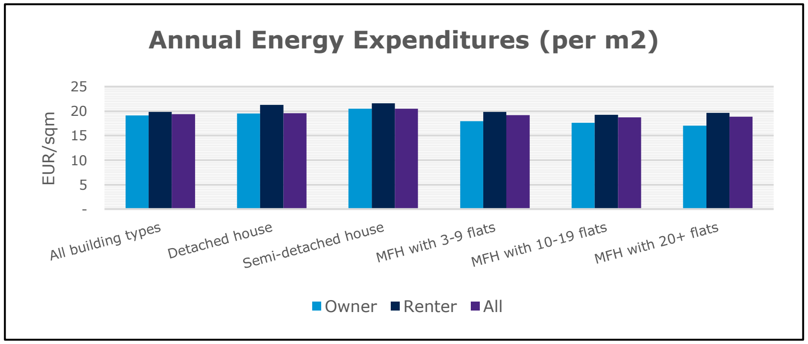

Determinants of Energy Expenditures

Variable	Austria-wide Coeff.	Austria-wide Std. Error
OWNER	0.041**	0.021
TYPE_SF	0.285***	0.035
TYPE_RH	0.269***	0.036
TYPE_MF3 (3-9 flats)	0.076***	0.029
TYPE_MF10 (10-19 flats)	0.017	0.029
VINTAGE < 1919	0.142***	0.036
VINTAGE 1919-1944	0.143***	0.043
VINTAGE 1945-1960	0.122***	0.037
VINTAGE 1961-1970	0.091***	0.036
VINTAGE 1971-1980	0.118***	0.035
VINTAGE 1981-1990	0.137***	0.034
VINTAGE 1991-2000	0.055	0.033
VINTAGE 2001-2005	0.049	0.036
L_SIZE	-0.067	0.088
PROBLEM	0.031	0.023
HEAT_C	0.208***	0.043
FUEL_Gas	0.283***	0.027
FUEL_Oil	0.560***	0.025
FUEL_Wood	0.120***	0.022

- Owner actually increases energy costs
  - Net effect of being an owner in Austria increases energy expenditures per sqm by 4%
- Building characteristics
  - Detached/Semi-detached are more costly than Multifamily with 20 or more flats
  - Older buildings are more costly with a dip in the 1961-1970 category
  - Buildings build after 2000 are not statistically sig.
  - Size of dwelling has a negative impact and sig. impact (see *Backup* for explanation)
- Fuel variables
  - Oil and coal are the most costly
  - Wood and electricity-only are significantly less costly
  - Renewable sources reduce costs

Determinants of Energy Expenditures

Variable	Austria-wide	
	Coeff.	Std. Error
FUEL_Coal	0.253***	0.041
FUEL_None (electricity)	0.132***	0.031
RENEW	-0.110***	0.021
NOTPAID (ref. to fuel only)	-0.335***	0.026
L_INCOME	0.032***	0.011
ADULTS	0.084***	0.010
CHILDREN	0.054***	0.009
L_AGE	0.035	0.034
UNEMPL	0.076***	0.029
PENSION	0.021	0.013
STATE_NO (Lower Austria)	0.094**	0.036
STATE_W (Vienna)	0.113***	0.044
STATE_VO (Vorarlberg)	-0.186***	0.051
STATE_OO (Upper Austria)	0.041	0.037
STATE_SZ (Salzburg)	0.111**	0.044
STATE_TR (Tyrol)	-0.037	0.041
STATE_KA (Carinthia)	0.111**	0.043
STATE_ST (Styria)	0.097***	0.037
Constant	*4.117****	*0.210*

- Socio-economic variables
  - Income elasticity of 0.032 → comparable to prev. findings of 0.01-0.17
  - Nr. of adults and children both sig.
  - Nr. of unemployed sig. (pensioners not)
  - Age of oldest household member not significant → contrary to previous studies
- Regional variables are interesting
  - Burgenland is the reference group
  - Upper Austria and Tyrol pay relatively the same as in Burgenland (i.e. not significant results)
  - Vienna, Lower Austria, Salzburg, Carinthia and Styria pay between 10-12% more than in Burgenland
  - Vorarlberg pays less than those in Burgenland
  - Urbanization variables (not shown) were both not statistically significant

Differences in Determinants: Regional

Variable	Vienna		Eastern		Western		Southern	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
OWNER	-0.067	0.046	0.013	0.051	0.116***	0.033	0.075**	0.044
TYPE_SF	0.375***	0.067	0.299***	0.088	0.278***	0.061	0.256***	0.075
TYPE_RH	0.299***	0.081	0.299***	0.096	0.246***	0.065	0.302***	0.083
TYPE_MF3	0.104***	0.053	0.094	0.088	0.054	0.052	0.149**	0.068
VINTAGE19	0.113	0.091	0.177**	0.079	0.051	0.063	0.176***	0.087
VINTAGE44	0.101	0.108	0.148*	0.087	0.096	0.073	0.210**	0.090
VINTAGE60	0.030	0.105	0.195**	0.083	0.062	0.060	0.200**	0.083
FUEL_Gas	0.347**	0.137	0.303***	0.042	0.243***	0.041	0.281***	0.062
FUEL_Wood	0.076	0.073	0.142***	0.040	0.139***	0.035	0.105**	0.051
FUEL_None	0.167	0.137	0.172***	0.062	0.088*	0.048	0.163**	0.063
L_INCOME	0.013	0.020	0.006	0.025	0.064***	0.020	0.049**	0.022
ADULTS	0.131***	0.025	0.068***	0.022	0.076***	0.017	0.070***	0.020
CHILDREN	0.032	0.023	0.029	0.020	0.081***	0.015	0.048**	0.021
L_AGE	0.018	0.066	-0.011	0.077	0.169***	0.057	-0.111	0.075
UNEMPL	0.106*	0.055	0.129**	0.064	0.020	0.050	0.051	0.064
Constant	*4.299****	*0.396*	*4.495****	*0.436*	*3.137****	*0.405*	*4.523****	*0.454*

- Building type remain sig. across all regions with similar effects
- Building vintage remains sig. only in E. and S. Austria
- Fuel variables remain sig., except in Vienna where only oil (not shown) and gas remain sig.
- Income elasticity ranges from 0.01-0.06 and is not sig. in Vienna or E. Austria
- Nr. of children is not statistically sig. in Vienna or E. Austria
- Net effect of being an owner remains both positive and sig., except in Vienna and E. Austria
- Principal-agent problems appear to not have a significant effect on energy expenditures in the various regions in Austria
- Results of socio-economic variables vary in their significance across the regions in Austria, especially income elasticity

Differences in Determinants: Tenure

	Austria-wide		Owners		Renters	
Variable	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
OWNER	0.041**	0.021	--	--	--	--
TYPE_SF	0.285***	0.035	0.416***	0.049	0.110*	0.066
TYPE_RH	0.269***	0.036	0.376***	0.052	0.225***	0.055
TYPE_MF3	0.076***	0.029	0.208***	0.049	0.022	0.036
VINTAGE19	0.142***	0.036	0.208***	0.046	0.073	0.064
VINTAGE44	0.143***	0.043	0.178***	0.053	0.114	0.074
VINTAGE60	0.122***	0.037	0.171***	0.046	0.068	0.066
FUEL_Gas	0.283***	0.043	0.281***	0.027	0.258***	0.089
FUEL_Wood	0.120***	0.022	0.090***	0.022	0.184**	0.071
FUEL_None	0.132***	0.031	0.092**	0.036	0.133	0.089
L_INCOME	0.032***	0.011	0.055***	0.015	0.006	0.018
ADULTS	0.084***	0.010	0.059***	0.012	0.147***	0.019
CHILDREN	0.054***	0.009	0.049***	0.011	0.058***	0.016
L_AGE	0.035	0.034	-0.045	0.051	0.110**	0.046
UNEMPL	0.076***	0.029	-0.026	0.038	0.132***	0.041
Constant	*4.117****	*0.210*	*4.259****	*0.301*	*3.960****	*0.313*

- Building characteristics are significantly more important for owners and renters, especially in the case of vintage
- Structural problems (not shown) are sig. for renters and increase expenditures by 9%
- Wood is twice as costly for renters than owners; otherwise, fuel variables are similar for both groups
- Owners have an income elasticity of 0.05 and is statistically more sig. than for renters
- Nr. of adults is sig. for both groups but over twice as costly for renters than owners
- Unemployed household members is sig. for renters while pensioners (not shown) are more sig. for owners
- Regional variables (not shown) are statistically more sig. for renters than for owners
- Based on these observations, it is possible that there are differences among particular subgroups of owners and renters

Discussion & Conclusions

EU SILC for Energy Research

Policy Implications

Conclusions

Policy Implications

- Regional energy efficiency policies should target owners and renters, separately
- After tenure, policies should differentiate based on type of building and income
- Policy measures could include information campaigns, tax benefits, subsidies or grants with more refined targeting aims (Schaefer et al. 2000)
- In Austria for example, policies should target:
  - Owners in detached and semi-detached housing (at the national level)
  - Owners (of any building type) in Western Austria (at the regional level)

EU SILC for Energy Research

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- Limited energy-related questions included in the survey
- Main focus of statistics is on income, social exclusion, poverty
- 2012 survey was a special case due to ad hoc module
- Lack of energy-related data ultimately renders SILC unsuitable for energy topics
- Exception is energy poverty
- Methodological issues in SILC also limit usefulness for residential energy research
- Haffner (2015) notes:
  - Limitation in distinguishing needs of housing studies from those of poverty studies
  - Limitation in differentiating specific costs related to energy uses (e.g. space heating, cooking)
  - Limitation in distinguishing effects of government instruments (e.g. subsidies, tax benefits)

- Scope of current study was limited to a single year
- Cannot take advantage of the full panel features of SILC concerning residential energy demand

Conclusions

- Determinants of Austrian household energy expenditure vary across regions and type of household
- Principal-agent problems were not detected in the analysis
- EU SILC provides socio-economic variables necessary for energy-related research

- In particular socio-economic factors vary strongly between owners and renters
- All else equal, the net effect of being an owner increases energy expenditure in Austria
- But lacks the granulation level necessary for comparability in energy topics and is restricted to a single year

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* Full reference list is available in the full paper and upon request.

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Grazie per l'attenzione!

Vielen Dank für Ihre Aufmerksamkeit!

Thank you for your attention!

Any questions or feedback is greatly appreciated

Backup

Additional information

Interpretation of Dummy Coefficients

Following Halvorsen and Palmquist (1980), in the case of dummy variables, percentage change values are computed as

$$\Delta\% = \exp(\beta_i) - 1$$

from the OLS results, where β_i is the respective OLE coefficient

Interpretation of HEAT_C

Why build a central heating system if it increases costs?

The variable is unitary, indicating the presence of central heating (e.g. district heating, gas convection, etc.) or not (e.g. oil or wood stove). The interpretation here is that “a central heating system increases expenditures by (coefficient) compared to a single-stove.”

Negative L_SIZE

Mathematically, the regression results and functional form are identical, whether the dependent variable is divided by sqm or not, due to the inclusion of L_SIZE. When the dependent variable is not divided by sqm, L_SIZE is positive, as expected, which can be obtained by adding one to the coefficient of L_SIZE of the function used in this analysis (note: $\log(SIZE) = L\_SIZE$):

$$\log \frac{y}{\boldsymbol{SIZE}} = a + \beta_1 x + \boldsymbol{\beta_2} \mathbf{log}\, \boldsymbol{SIZE} + \varepsilon$$

$$\log y - \mathbf{log}\, \boldsymbol{SIZE} = a + \beta_1 x + \boldsymbol{\beta_2} \mathbf{log}\, \boldsymbol{SIZE} + \varepsilon$$

$$\log y = a + \beta_1 x + \mathbf{log}\, \boldsymbol{SIZE} + \boldsymbol{\beta_2} \mathbf{log}\, \boldsymbol{SIZE} + \varepsilon$$

$$\log y = a + \beta_1 x + (\mathbf{1} + \boldsymbol{\beta_2}) \mathbf{log}\, \boldsymbol{SIZE} + \varepsilon$$