

# Heterogeneity in Residential Electricity Consumption: A Quantile Regression Approach

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# Motivation

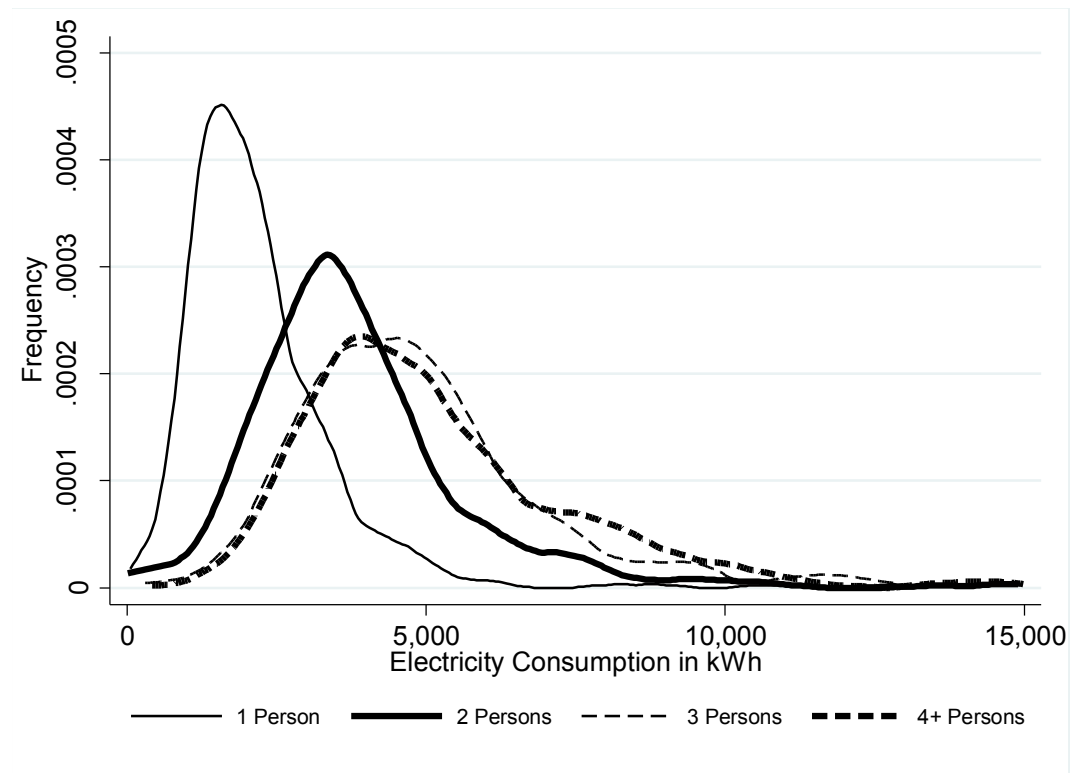
- Germany aims at a 10% reduction in electricity consumption by 2020
- Several measures are in place to achieve this target, including information on electricity saving potential
- Little is known about the actual extent of saving potentials
- In the absence of metering data, the conditional demand approach is widely used

# Data

- We draw on data from two subsequent surveys that were jointly conducted as part of the German Residential Energy Survey (GRECS)
- 8,500 households disclosed billing data and socio-economic characteristics
- 2,100 households with validated consumption figures were randomly selected to gather information on the appliance stock and its utilization

# Electricity Consumption

- Heterogenous consumption with respect to household size



## Appliance Stock and Utilization Behavior

Variable	Type	Mean	Std. Dev.	Nr. of Obs.
1 Person Household	Dummy	0.308	–	2,105
2 Person Household	Dummy	0.422	–	2,105
3 Person Household	Dummy	0.140	–	2,105
4+ Person Household	Dummy	0.130	–	2,105
Dishwashing cycles	Count	186	112	1,674
Washing cycles	Count	185	147	1,991
Drying cycles	Count	98	98	1,130
Refrigerators	Count	1.35	0.58	2,050
Freezers	Count	0.72	0.64	2,085
TV sets	Count	1.73	0.89	2,054
Aquarium or terrarium	Dummy	0.06	–	2,094
Water heating	Dummy	0.18	–	2,106

## Conditional Demand Approach

- Slight modification of Larsen and Nesbakken (2004)

$$y_{\downarrow i} = y_{\downarrow 0} + \sum_{j \uparrow} \beta_{\downarrow j} D_{\downarrow ij} + \sum_{k \uparrow} \gamma_{\downarrow k} N_{\downarrow ik} + z_{\downarrow i} + \varepsilon_{\downarrow i}$$

- $D_{\downarrow ij}$ : Dummy whether household  $i$  holds appliance  $j$
- $N_{\downarrow ik}$ : Number of appliance  $k$  held by household  $i$
- To account for heterogeneity correction factor  $z_{\downarrow i}$  is included

$$z_{\downarrow i} = \sum_{j \uparrow} \sum_{m \uparrow} \rho_{\downarrow jm} (C_{\downarrow im} - C_{\downarrow jm}) D_{\downarrow ij} + \sum_{k \uparrow} \sum_{m \uparrow} \rho_{\downarrow km} (C_{\downarrow im} - C_{\downarrow jm}) N_{\downarrow ik}$$

## Quantile Regression Approach

- Usually, OLS or GLS are applied to estimate conditional demand models
- To provide a more complete picture between electricity consumption and its determinants => Quantile Regression (Koenker, Bassett, 1982)
- Thereby, we can study the impact of a regressor on the full distribution of  $\mathcal{Y}$ , not just of the conditional mean

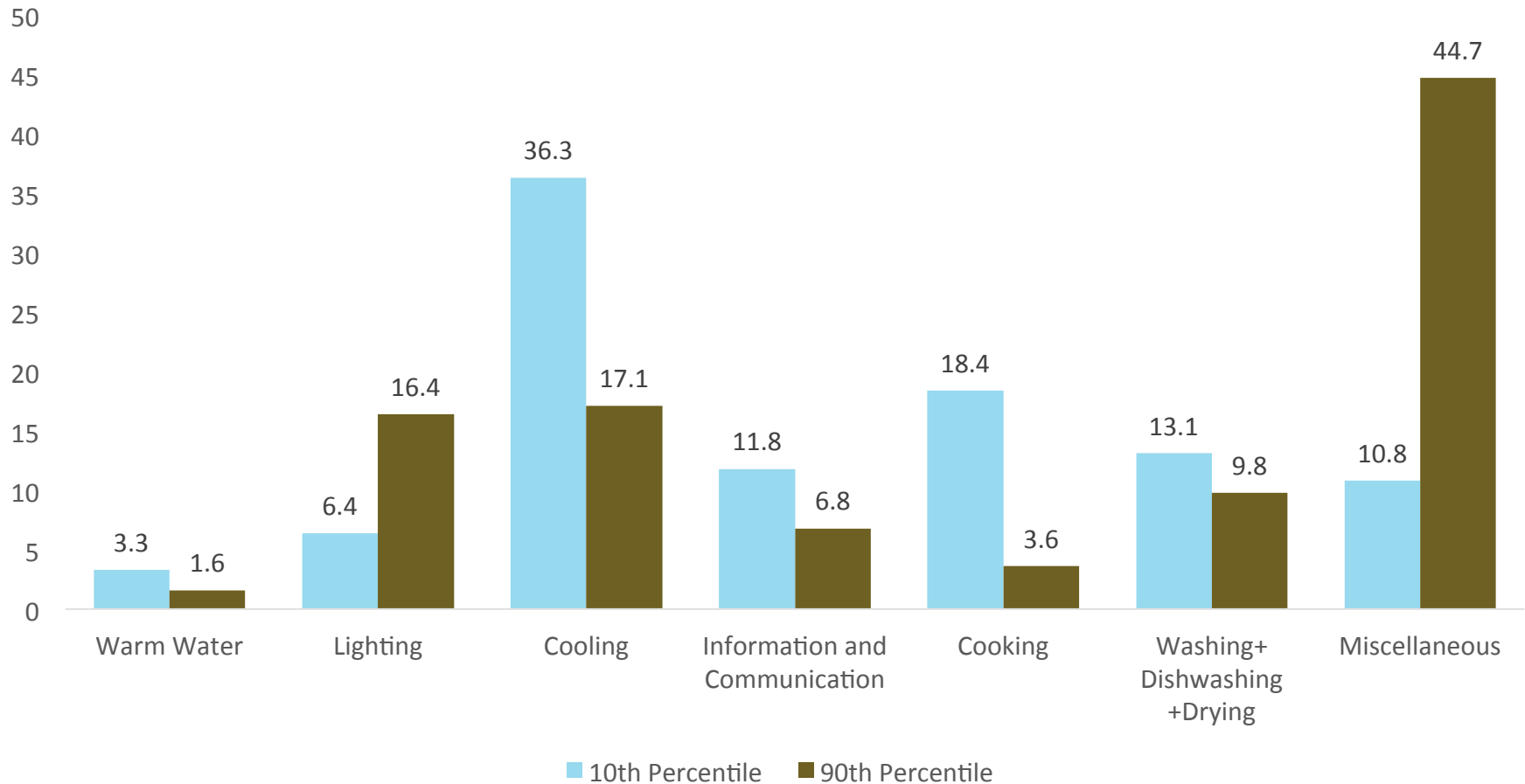
## Comparison of Estimation Results

Variable	OLS	10th	50th	90th
2 Members	834.2**	419.6**	710.0**	1,126.5**
3 Members	1,370.0**	848.9**	1,244.4**	1,773.2**
4+ Members	1,356.5**	922.0**	1,164.5**	1,862.7**
Water heating	466.8**	266.2**	512.3**	615.8*
Per refrigerator	303.2**	322.5**	374.5**	391.9**
Per freezer	402.4**	248.8**	445.0**	534.8**
Per washing cycle	0.68	0.37	0.46*	-0.27
Per dish washing cycle	1.27**	1.52**	1.45**	1.98**
Per drying cycle	2.79**	2.40**	2.84**	3.07**
Per TV set	113.8**	93.0**	134.4**	118.2
Per light bulb	10.22**	4.64**	4.75	32.6**

Note: Robust standard errors are reported; \* denotes significance at the 5% level, \*\* at the 1% level. Number of observations used for estimation: 1,653.



# Shares of End-Use Purposes



# Conclusion

- There are huge savings potentials among German households, for instance with respect to freezers
- We recommend policies aimed at improving efficiency of the appliance stock to achieve energy conservation targets
- Since most of the electricity consumption is determined by habits, educational efforts should be undertaken to enable load-shifting



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Koenker, R., G. Bassett (1982) Robust Tests for Heteroscedasticity based on Regression Quantiles. *Econometrica* 50(1), 43-61.

Larsen, B. M., R. Nesbakken (2004) Household Electricity End-Use Consumption: Results from Econometric and Engineering Models. *Energy Economics* 26(2), 179-200.