The Amenity Cost of Traffic Noise

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Motivation

- Traffic noise is harmful to the health of almost every third person in the European Region (WHO Europe)
  - One in five Europeans is regularly exposed to sound levels at night that could significantly damage health
  - Effects: Annoyance, hypertension, cardiovascular diseases in the long term
- In Denmark 1/3 of all existing homes are exposed to road noise above the guideline limit for residential areas
- Measures undertaken to reduce noise, e.g.:
  - noise reducing asphalt and noise insulation
  - urban planning (zoning & traffic management)

What is the cost of noise?

What is noise?

- Noise is measured in dB on a logarithmic scale
- Increase of 10 dB corresponds to a doubling of the perceived sound level
- A 1 dB change is just perceivable
  - 40 dB corresponds to the sound of a whisper at 0.3 m distance
  - 50-55 dB is “urban background noise” in a residential neighbourhood
  - 100 dB is the sound measured 30 m from a propeller airplane
  - 120 dB is painful!
- Doubling the amount of traffic in a street increases noise levels by 3 dB

Hedonic method

- Hedonic method (Rosen, JPE 1974): Revealed preferences in the housing market
- Existing hedonic literature on cost of traffic noise is large (e.g. Nelson (2008))
  - First stage only: Noise Depreciation Index
  - Second stage is rarely carried out
- Little is known about who is noise sensitive and willingness to pay for non-marginal changes...

Research strategy: First stage

Recovering hedonic price schedule $P(h, q; \theta)$:

- Measurement error
  - Single mapping of road noise measures used for whole sample
- Omitted variables
- Theory gives little guidance about functional form

- *Limit sample to homes near large roads*
- *Spatial fixed effects*
- *Flexible functional form - generalized additive model*

Research strategy: Second stage

Recovering preferences: $U(h, q, c; \beta)$:

- h: housing characteristics, q: quiet, c: non-housing consumption
- Unobserved taste coupled with nonlinear hedonic price function -> Endogeneity
- Instruments are hard to come by due to sorting
- *Functional form restrictions - Bajari & Kahn (2005):*

$$U(h, q, c) = \sum_k \beta_{ki} log(h_{ki}) + \beta_{qi} log(q_i) + log(c_i)$$

From FOC:

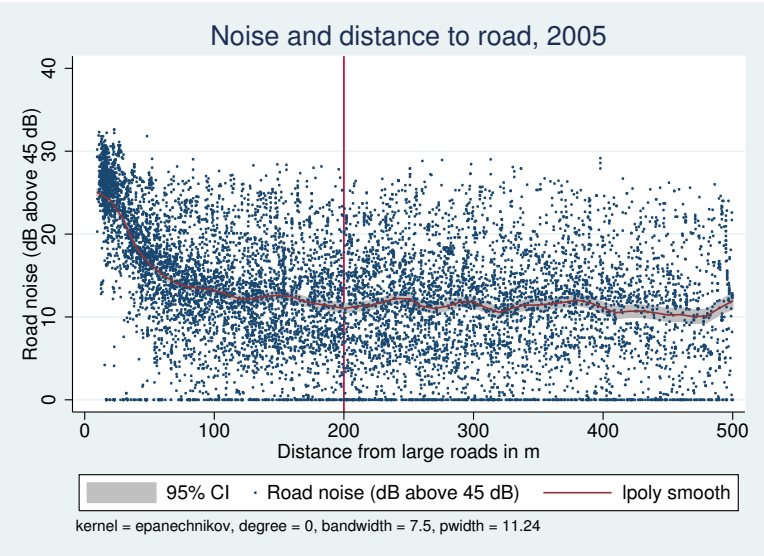
$$\beta_{qi} = \frac{\pi_t \left(\partial P / \partial q\right)_i (q_i)}{(y_i - \pi_t P_i)}$$

π_t :user cost of housing, y: household income

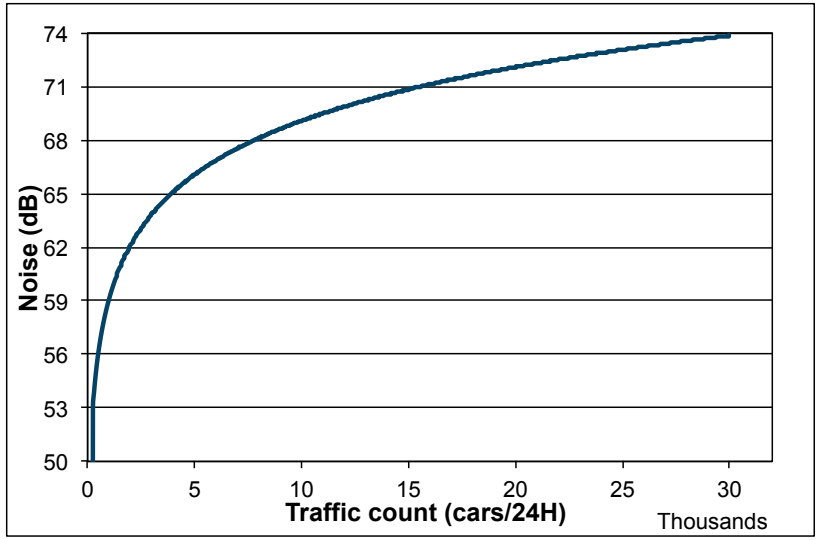
Data

- Data on housing transactions from 2000-2008, Greater Copenhagen area: 97,000 obs over 9 years
- Households living in the dwelling: Income, education, age, marital status, children etc.
- Noise measures: EU Noise Directive (2002)
- Noise is calculated as a Day-Evening-Night *weighted* average noise level for a year
- Based on 2005/6 traffic counts
- Main focus: Road noise
  - Calculated taking account of asphalt, barriers, traffic, speed, weather ($>$ 45 dB)
- Railway noise ($>$ 55 dB) and airport noise ($>$ 45 dB) also measured, but poorer quality

Measurement error: Spatial distribution of noise



Homes near large roads

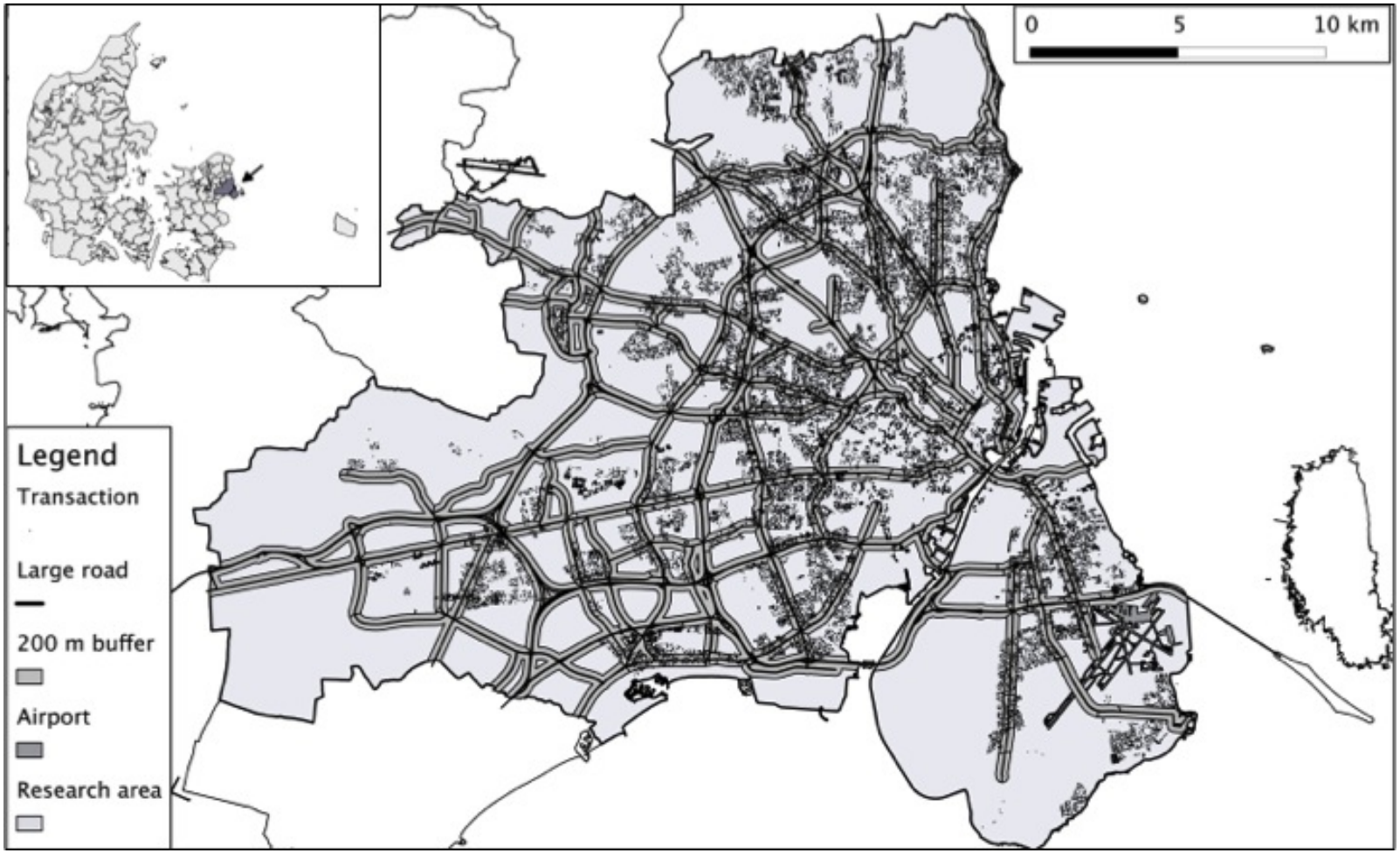


Traffic and noise

Limiting sample to within 200 m of large roads

- Enhances validity of the use of a single cross-section of noise measures
- Road border zone fixed effects to control for omitted neighborhood variables

Research area with 200 m buffers



Road border areas - the details

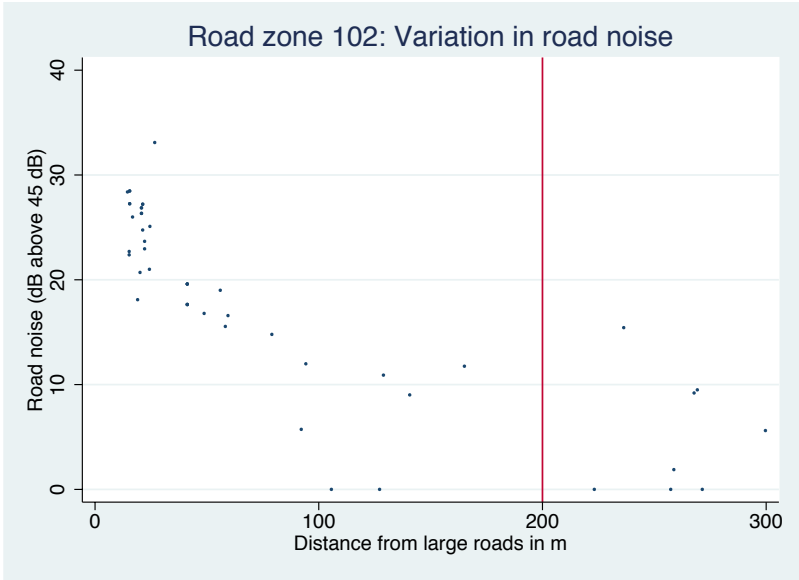


Table 2: Descriptives, road zones

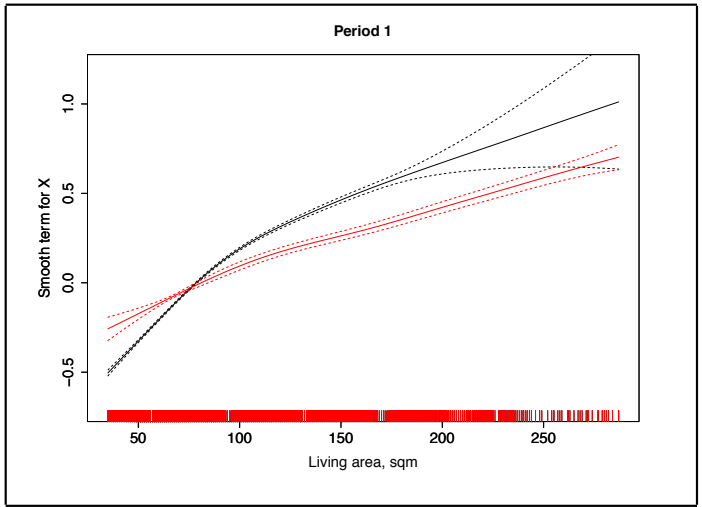
Period	2000-2002			2004-2005			2007-2008	
Transactions	15,073			9,889			5,347	
Road border zones	160			127			96	
Border zone stats	p5	p25	p50	p75	p95	mean	min	max
Area (km^2) - 200 m	0.30	0.42	0.52	0.67	0.88	0.54	0.17	0.95
Obs./period - 200 m	27	55	115	228	482	163	20	552

Functional form

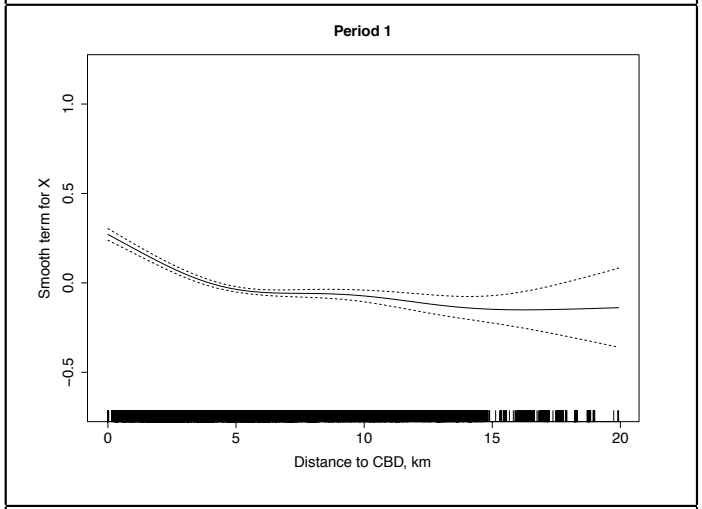
- Little guidance from theory on the appropriate functional form
- Generalized additive model:

$$g(E(P_i)) = X_i B + f_1(x_1) + f_2(x_2) + \ldots$$

- Logarithmic link function and Gamma distribution
- Fits smooth components with penalized splines: Living space, distance to CBD, noise exposure, ...
- Fixed effects: Period X road border zone id
- R^2 around 0.8 for each period

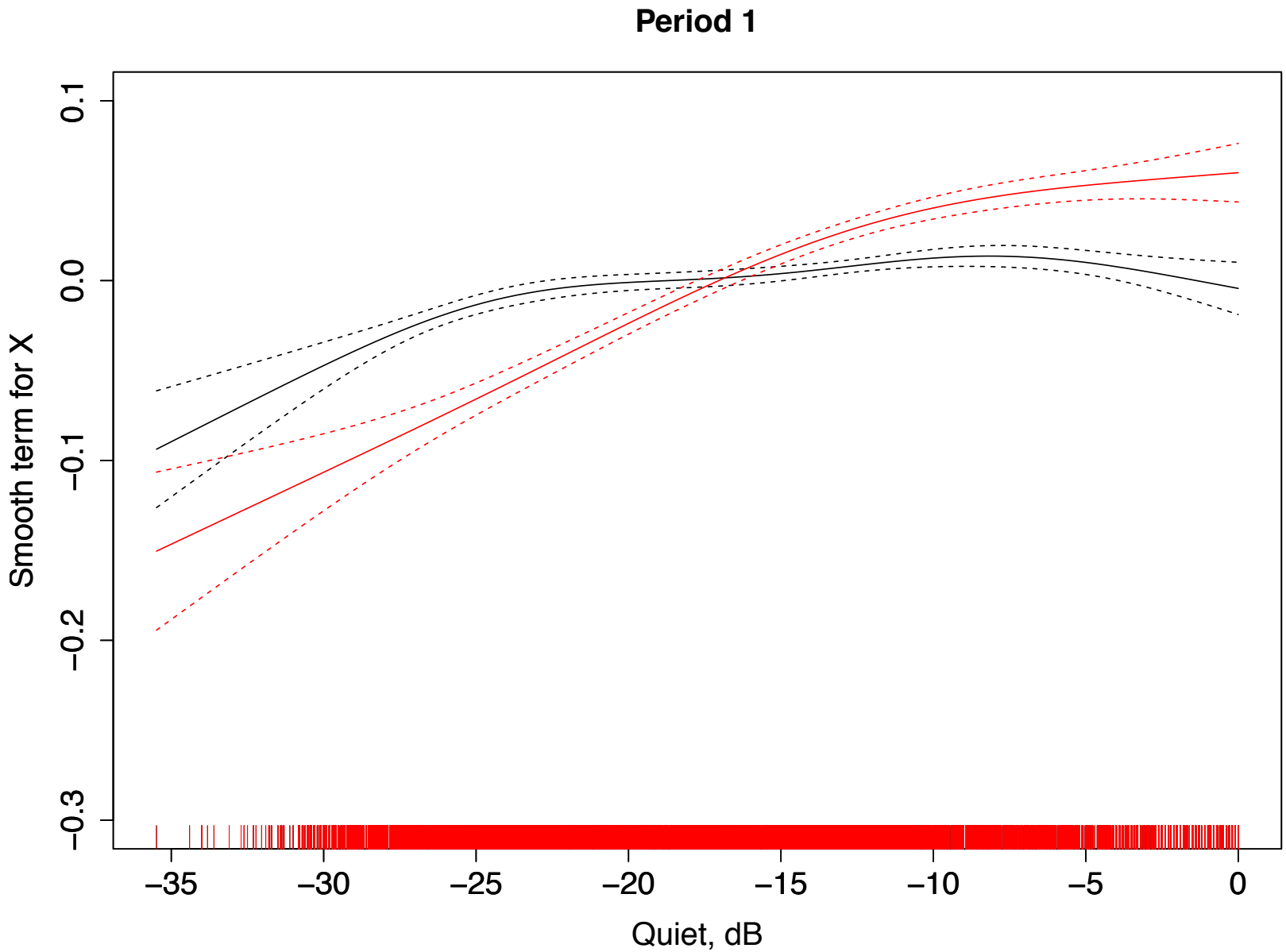


Living Area



Distance to CBD

Road noise


Period 1
Smooth term for X
0.1
0.0
−0.1
−0.2
−0.3
−35
−30
−25
−20
−15
−10
−5
0
Quiet, dB

Implicit prices and preference parameters

Implicit prices are calculated by finite differencing

Annual price	Min	1st Q	Median	Mean	3rd Q	Max
Quiet	-532	32	79	141	203	1,874
Living area	30	207	274	288	357	2,265
CBD	-457	438	1093	1482	2064	13,669

...and so preference parameters are

β_{ki}	Min	1st Q	Median	Mean	3rd Q	Max
Quiet	-0.14	0.00	0.01	0.01	0.02	0.33
Living space	0.01	0.07	0.10	0.14	0.16	4.09
Proximity to CBD	-0.01	0.02	0.08	0.16	0.21	3.70

Welfare estimates for noise reduction

Willingness to pay for noise reduction(DKK/year in 2000-prices)

WTP	Min	1st Q	Median	Mean	3rd Q	Max
62 to 60 dB	0	82	156	268	343	3,346
72 to 70 dB	1	161	305	525	671	6,515
70 to 60 dB	2	526	996	1,708	2,187	20,755
61 to 60 dB	0	40	76	131	167	1,637
dP/dq	0	40	89	156	216	1,874

- Mean noise level in 200 m sample is 60.6 dB
- Increasing willingness to pay to lower noise at higher noise levels
- Median WTP for 10 dB decrease: $ 230/year in today's prices

For comparison: Bajari & Kahn (2005) found a median annual WTP for an increase from 4 to 6 rooms at approx. $ 500 in today's prices

Preference heterogeneity

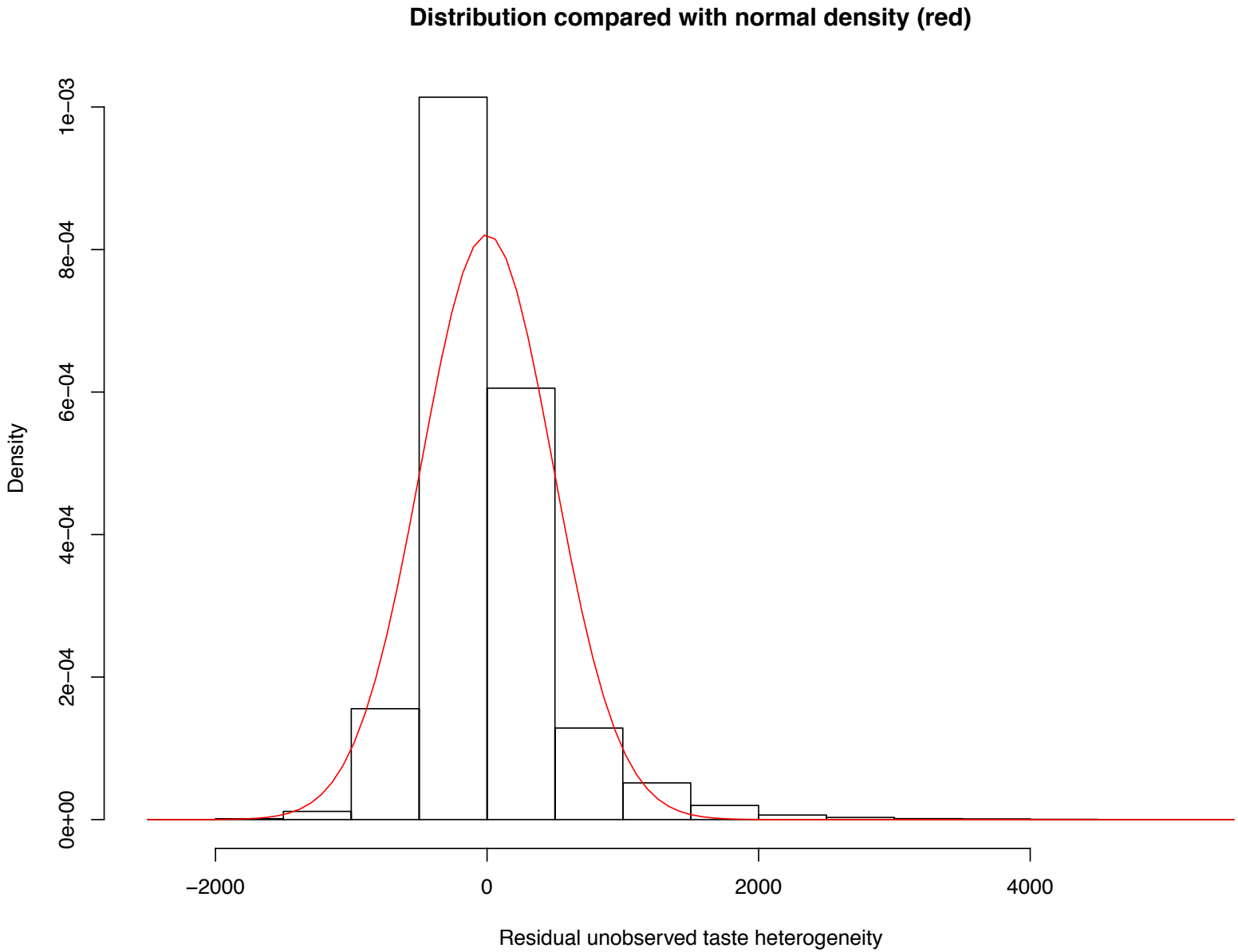
Welfare estimates explained by demographic characteristics

WTP 72 to 70 dB	Estimate	Std. Error	Pr(>|t|)
(Intercept)	-308.20	28.85	0.0000
Age	13.83	1.30	0.0000
Age sq.	-0.07	0.01	0.0000
Male	-13.94	8.50	0.1013
Education < highschool	-38.42	13.67	0.0049
- Vocational training	-32.29	10.80	0.0028
- Bachelor	-45.33	16.11	0.0049
- Short-medium length studies	-30.35	11.52	0.0084
- Masters degree	-46.05	12.10	0.0001
- PhD	-77.05	15.67	0.0000
Part time work	32.28	9.07	0.0004
Foreign born	-46.32	8.82	0.0000
Not owner-occupied	43.01	9.30	0.0000
Retired	-76.96	22.68	0.0007
Student	-21.36	11.72	0.0683
Income (thousands)	1.59	0.03	0.0000
Additional controls: children, household size, married (all pos.sign)			

Omitted: Education: highschool graduate

Explained heterogeneity R^2 : 0.32

Preference heterogeneity, unexplained



Conclusions

- Traffic noise lowers house prices
- Difference between using marginal WTP estimates and welfare estimates from utility function: Annoyance increases in noise levels
- Preference heterogeneity: 32 % explained by observables but 68 % of variation in WTP for quiet unexplained

Future work

- Set higher level of background noise for apartments
- Leaving hedonics: Discrete choice model, sorting model?

Thank you

Thank you for listening!
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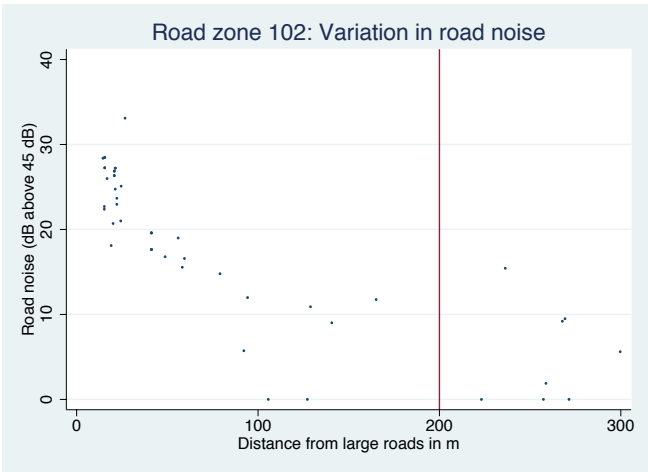
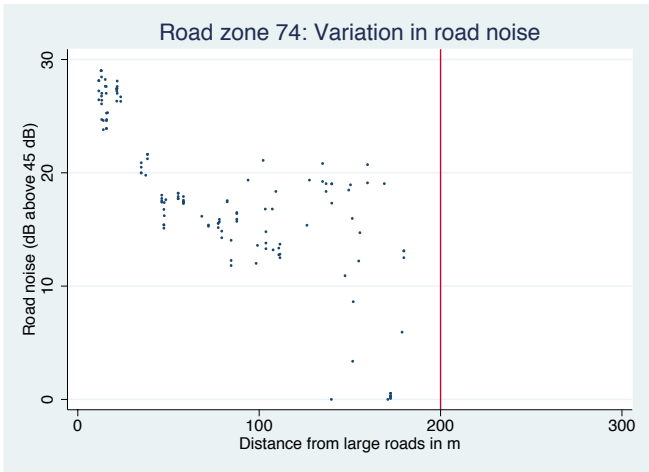
Thanks to the Danish Economic Council for providing data

Noise variation within road zones

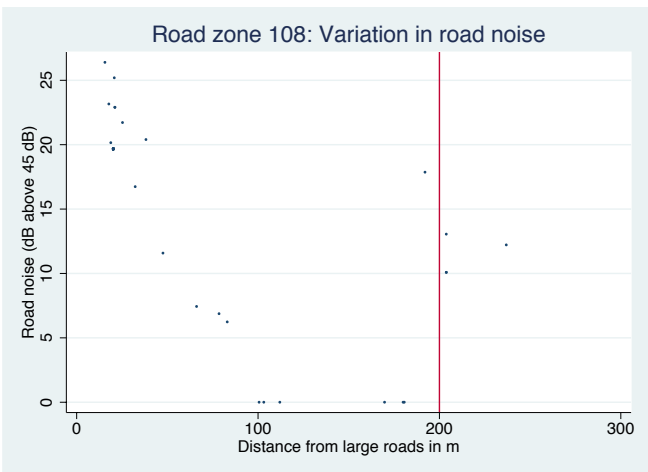
(a) Ex. 1



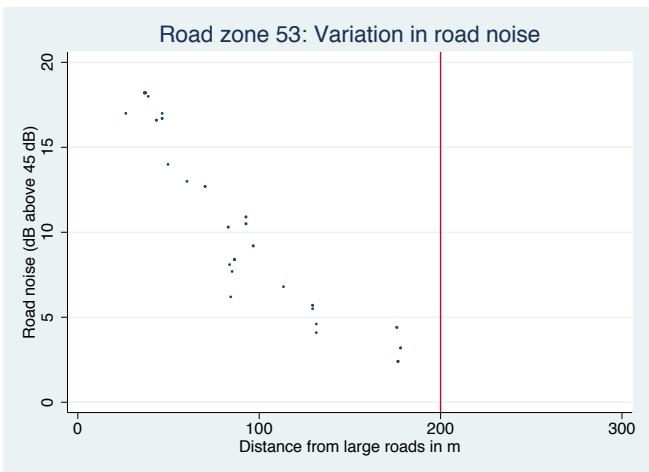
(c) Ex. 3



(b) Ex. 2



(d) Ex. 4



User cost of housing