Shadow Prices of Externalities in Transport

An Empirical Study on Value of Noise in the Czech Republic

Patrik SIEBER
Department of Business Economics
University of Economics, Prague
patrik.sieber@vse.cz

Jan MELICHAR
Charles University Environment Center
jan.melichar@czp.cuni.cz

Project : Shadow Prices of Externalities in Transport

- Project financed by Ministry of Transport (2007 – 2010) N. CG712-030-520
- Solved by: KPM Consult, a.s. and University of Economics, Prague
- Project Aims and Outcomes:
  - set of methodological guides and guidelines focused on concepts and methods of estimating particular non-marketed goods and dealing with risk within CBA framework
  - Empirical estimates of VSL, VTTS and Value of Noise from national point of view.

Project Empirical Part - Brief Overview

- Theoretical Concepts of Social Value Accepted: WTP, WTA (Compensating or Equivalent Variation)
- Valuated Change in comparison with Status quo: Time Savings, Changes in Household Noise Exposure and Statistical Lives and Injuries savings resulted from Transport Interventions.
- Relevant population: Nationally defined (Czech population)

Project Empirical Part – Brief Overview – Method Selection

- Potential Usage of Indirect Market Methods based on Revealed Preferences: **Strongly limited by data relevant from national perspective attainable**
  - There where analysed attainable data mainly from real estate market and labour market).
  - The data attainable did not allow to answer solved questions.
- The choice of method based on Stated Preferences instead was than accepted and for the quantitative part was used concept CVM (Contingent Valuation Method)

Quantitative Empirical Part - Sample

- Method: CVM, open question
- Values in question: VSL, VSInjury, VTTS, Value of Noise
- Date of Data Collection: break of 2009/2010
- Agency used: Millward Brown CR (SIMAR standards guaranteed, used over 100 questioners, no one provided more then 21 interviews)
- Technique: CAPI

Quantitative Empirical Part Overview

- The sampling plan was received by following way:
- Probabilistic Stratified Sampling in the Czech Republic combined with Quotas.
- In the first step is used division of Czech population into proportional categories by Size (population category) of Place of Residence (SPR).
- In the second step was within each category (SPR) used random sampling of city and street within the city from starting point of random walk.
- Quotas were than used for guarantying age and sex structure of Czech population from 18 – 69 years. Quotas were based on Czech Statistical Office Data.
- Sample size: n = 2,103

Place of Residence - Size of Population

	Relative Frequencies, %					
County	**Up to 5,000**	**5,000-19,999**	**20,000-49,999**	**50,000-99,999**	**Over 100,000**	**In Total**
Praha	0.0	0.0	0.0	0.0	100.0	100
Stredocesky	55.2	21.9	17.2	5.8	0.0	100
Jihocesky	48.4	19.0	17.6	15.0	0.0	100
Plzensky	49.0	17.5	4.1	0.0	29.5	100
Karlovarsky	32.8	31.2	19.3	16.7	0.0	100
Ustecky	28.6	24.7	14.6	32.1	0.0	100
Liberecky	36.2	21.6	19.2	23.0	0.0	100
Kralovehradecky	42.6	30.9	9.4	17.1	0.0	100
Pardubicky	48.1	29.9	4.6	17.5	0.0	100
Vysocina	50.6	22.7	16.9	9.9	0.0	100
Jihomoravsky	45.0	11.5	11.2	0.0	32.3	100
Olomoucky	49.0	16.6	18.8	0.0	15.6	100
Zlinsky	45.3	22.8	18.7	13.2	0.0	100
Moravskoslezsky	25.2	13.4	15.5	21.2	24.7	100
In Total	37.5	17.9	12.7	11.2	20.8	

Age quotas based on ČSÚ (Czech Statistical Office)

	Relative Frequencies, %					
County\Age	**18-29**	**30-39**	**40-49**	**50-59**	**60-69**	**In Total**
Hl.m.Praha	24	23	17	20	16	100
STČ kraj	23	23	18	20	15	100
JIČ kraj	24	22	18	21	15	100
PLZ kraj	23	22	18	21	16	100
KVA kraj	24	22	18	21	15	100
ÚST kraj	24	23	18	21	15	100
LIB kraj	24	23	17	21	15	100
KHR kraj	23	22	18	21	16	100
PAR kraj	24	22	18	21	15	100
VYS kraj	24	22	19	20	15	100
JIM kraj	24	22	18	20	16	100
OLM kraj	24	22	18	20	15	100
ZLN kraj	24	22	19	20	15	100
MSL kraj	24	22	19	20	15	100

Sex quotas based on ČSÚ (Czech Statistical Office)

	Relative Frequencies, %		
County\sex	**Mail**	**Femail**	**In Total**
Praha	50	50	**100**
Stredocesky	51	49	**100**
Jihocesky	51	49	**100**
Plzensky	51	49	**100**
Karlovarsky	51	49	**100**
Ustecky	51	49	**100**
Liberecky	50	50	**100**
Kralovehradecky	51	49	**100**
Pardubicky	51	49	**100**
Vysocina	51	49	**100**
Jihomoravsky	51	49	**100**
Olomoucky	51	49	**100**
Zlinsky	51	49	**100**
Moravskoslezsky	51	49	**100**

2nd Part

An Empirical Study on Value of Noise in the Czech Republic

- Contingent valuation method (CVM) on valuation of road traffic noise
- Willingness-to-pay (WTP) elicit using open-ended (OE) question
- High incidence of null WTP as in other CVM applications using OE format
- Our analysis of CVM data $\Rightarrow$ sample mean of WTP variable
  1. Non-parametric technique for estimating a survival function for WTP responses
  2. Econometric estimation of a bid function where we deal with the large numbers of zero responses (Double-Hurdle specification)

WTP estimates for change of road traffic noise by 1 dB per household and year (CZK of 2010)

Study	Method	Site	Scenario	WTP (1 dB)
Navrud (1997)	CVM	Norway	E	60
Barreiro et al. (2000)	CVM	Pamplona, Spain	E	60-90
Sieber et al. (2011)	CVM	Czech Republic	10 dB	131-450
Máca et al. (2009)	CVM, WTA	4 cities, Czech Republic	E	163-1 378-2 256*
Vainio (1995, 2001)	CVM	Helsinki, Finland	E	180-270
Lambert et al. (2001)	CVM	Rhône-Alpes, France	E	210
Thune-Larsen (1995)	CVM	Oslo and Ullensaker, Norway	%	570
Navrud (2000)	CVM	Oslo, Norway	E	690-961
Wibe (1997)	CVM	Sweden	E	841
Wardman, Bristow (2004)	CE	Edinburg, UK	%	1 111-1 651
Sælinsminde (1999)	CE	Oslo and Akerhus, Norway	%	1 441-2 882
Arsenio et al. (2006)	CE	Lisbon, Portugal	L	1 651
Soguel (1994)	CVM	Neuchâtel, Switzerland	%	1 801-2 132
Pommerehne (1988)	CVM	Basle, Switzerland	%	2 972

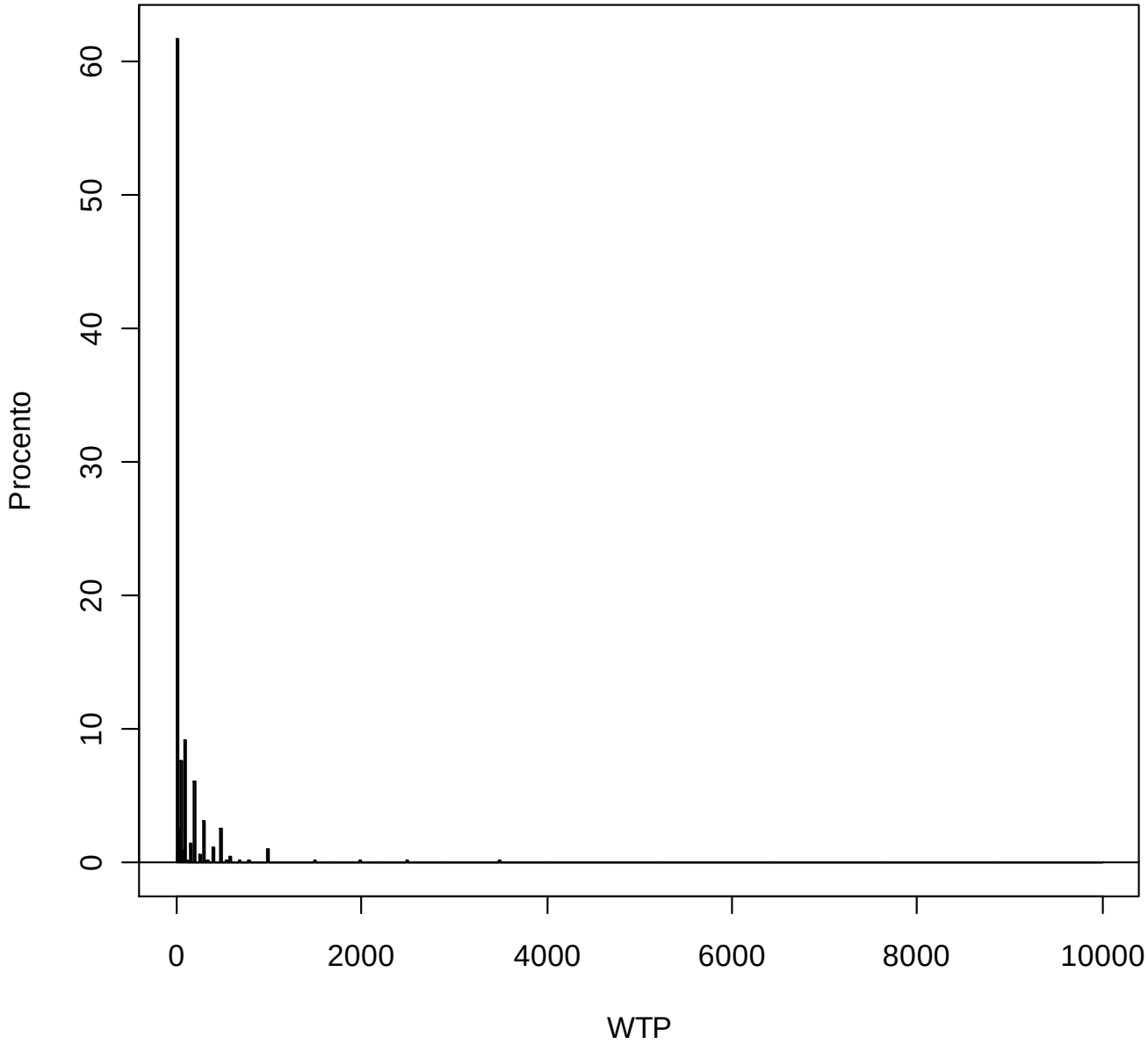
Notes: % - percentage change in noise levels, O – elimination of annoyance from noise, L – change to level in a known location, *values in range L_{dvn} 43-70-81 dB(A)

Source: adjusted according to Nellthorp et al. (2007), Navrud (2004), Máca et al. (2010)

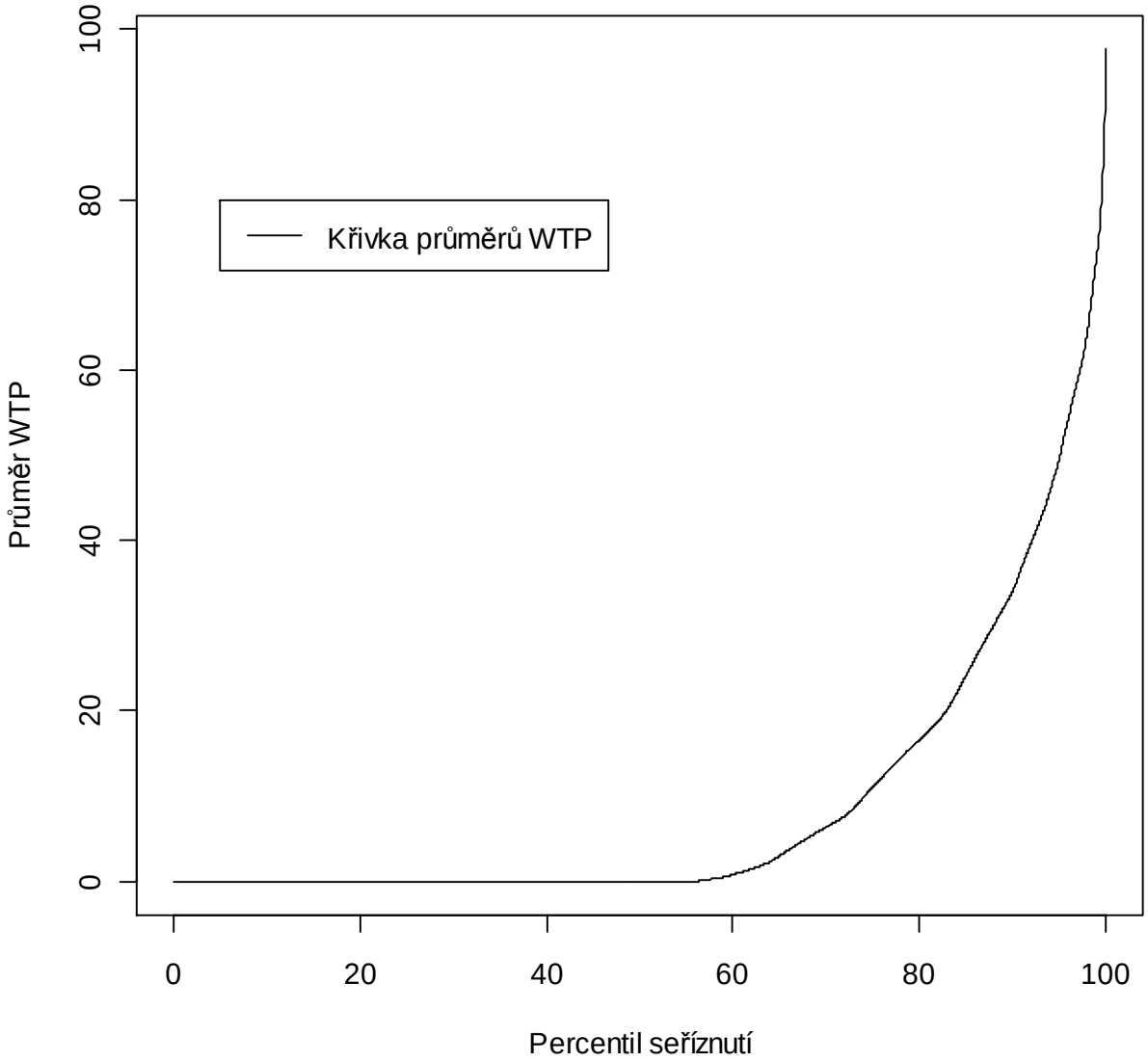
CVM scenario

- Standardized questionnaire:
  1. Socio-demographic characteristics
  2. Contingent exercise
  3. Economic characteristics of household
  4. Site characteristics of household
- Contingent scenario for the WTP elicitation
  - Audio projections of road traffic noise on calibrated notebooks
  - Such a level of noise heard at the open window in the place where he / she permanently lives
  - A audio record with loudness of 70 dB(A) lasting 40 sec
  - B audio record with loudness of 60 dB(A) lasting 40 sec
  - Open-ended question: Willingness-to pay each month for improvements reducing the noise level as heard on the audio record A and B

Histogram of willingness-to-pay for a reduction of noise level by 10 dB, N =2,103 (CZK, 2010)



Mean of willingness-to-pay according to percentile truncated (CZK, 2010)



Percentil of WTP

100th	97.65
99th	73.47
95th	49.62

Non-parametric (Kaplan-Meier) estimates of willingness-to-pay (CZK, 2010)

Survival function

$$\hat{S}(WTP_j) = \frac{n_j}{N}, j = 0,\ldots,J$$

Total number of households in the sample with a WTP higher than WTP_j

where

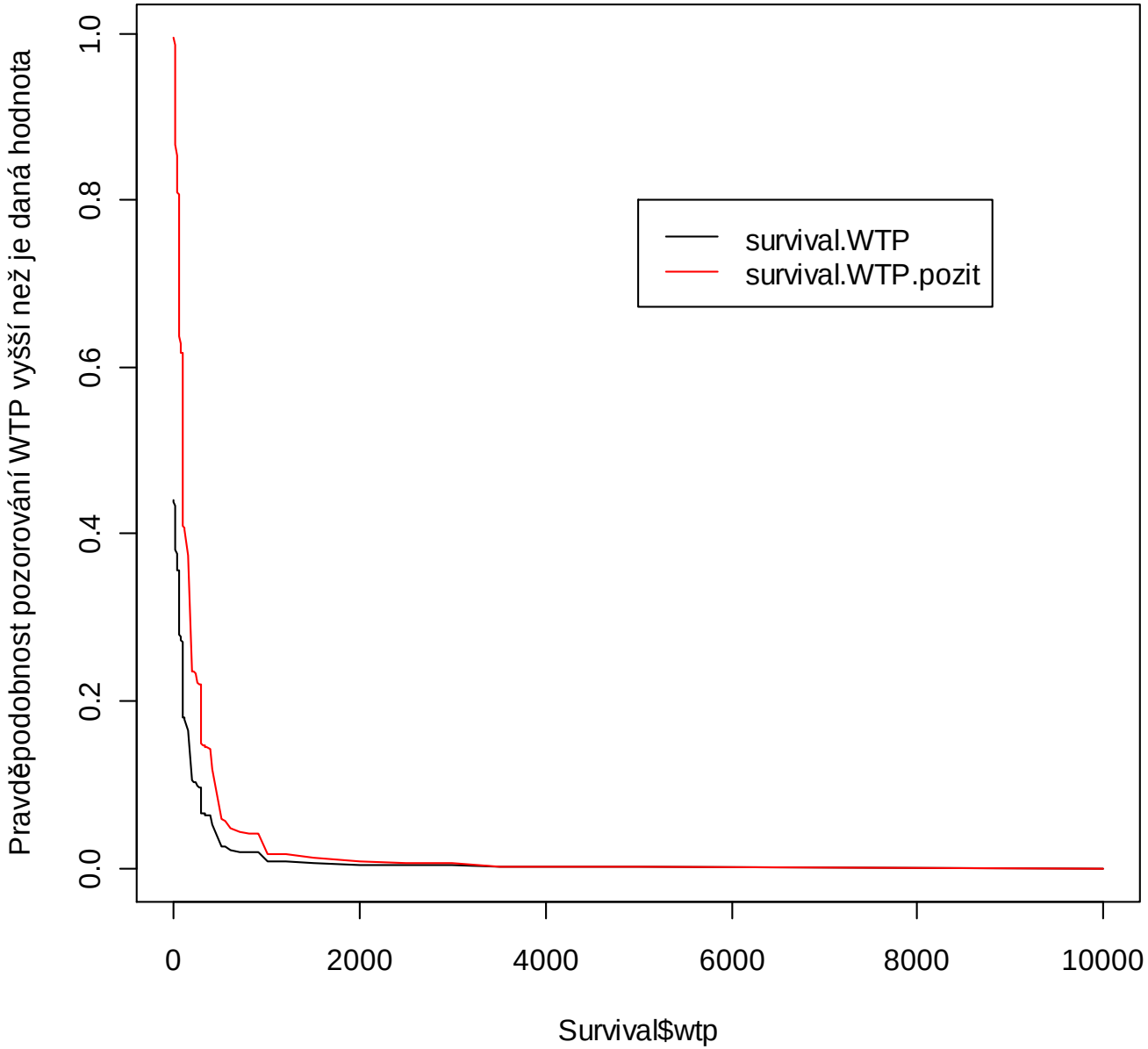
$$n_j = \sum_{k=j+1}^{J} h_k$$

Mean value

$$\overline{WTP} = \sum_{j=0}^{J} \hat{S}(WTP_j)[WTP_{j+1} - WTP_j]$$

	N	Median	Mean	Stand. err	95 % confidence interval	
WTP	2057	0	97.65	7.67	82.61	112.69
WTP.pozit	907	100	221.45	16.51	189.06	253.85

Kaplan-Meier survival function of WTP (CZK, 2010)



Double-Hurdle model

- Individuals make two decisions:
  1. Whether they will state any positive amount at all
  2. The height of positive amount, conditional on the first decision
- A participation (D), D* is a latent participation variable

$$D_i = 1 \text{ if } D^*_i > 0 \text{ and } 0 \text{ if } D^*_i \leq 0$$

$$D_i^* = Z_i\theta + u_i$$

- A level of participation (WTP)

$$\begin{cases} WTP_i = WTP^*_i \text{ if } WTP^*_i > 0 \text{ and } 0 \text{ if } D^*_i > 0 \\ WTP_i = 0 \quad \text{otherwise} \\ WTP_i^* = X_i\beta + e_i \\ \ln(WTP_i^*) = X_i\beta + e_i \end{cases}$$

Descriptive statistics, N= 1,495

Variable	Description	Mean	Stan. err
DEPENDENT VARIABLE			
D	Dummy: 1 = participation in the noise reduction programe	0.47	0.50
wtp	Monthly WTP for the noise reduction in CZK	109.34	388.75
SOCI-ECONOMIC CHARACTERISTICS			
income	Net monthly income in thous. CZK	14.33	5.41
rent	Monthly rent in thous. CZK	1.70	2.26
women	Dummy: 1 = women, 0 = man	0.51	0.50
age	Age	43.04	14.23
univ	Dummy: 1 = university degree, 0 = other	0.10	0.30
empl	Dummy: 1 = employee entrepreneur, 0 = other	0.74	0.44
married	Dummy: 1 = married, 0 = other	0.60	0.49
person	Number of persons in the household	2.86	1.17
living	Dummy: 1 = good standard of living, 0 = bad standard	0.35	0.48
NOISE CHARACTERISTICS			
city	Dummy: 1 = city of 50 th. and more people, 0 = other	0.29	0.45
village	Dummy: 1 = village under 5 th. inhabitans, 0 = other	0.39	0.49
apart	Dummy: 1 = apartment building, 0 = other	0.28	0.45
decibel	The average noise level at the open window in dB	57.01	9.29
noise	Dummy: 1 = high noise level at the open window, 0 = other	0.33	0.47
street	Dummy: 1 = most windows oriented to the street, 0 = other	0.33	0.47
higher	Dummy: 1 = noise levels higher than the record	0.06	0.23

Subsample of 1,495 observations for which we have all observable values for all analysed variables

Duble-Hurdle econometric estimates

Probit model				Log-normal model			
Variable	**Coeff.**	**P-value**	**Marginal effect**	**Variable**	**Coeff.**	**P-value**	**Marginal effect**
(Intercept)	-1.762	0.000	-	**(Intercept)**	3.671	0.000	-
women	0.132	0.048	0.052	**income**	0.053	0.000	12.68
univ	0.310	0.006	0.123	**rent**	0.188	0.000	45.25
empl	0.284	0.000	0.111	**rent²**	-0.021	0.002	-5.12
1/person	-0.324	0.034	0.129	**women**	0.292	0.003	70.10
living	0.201	0.005	0.080	**age**	-0.015	0.000	-3.65
village	0.356	0.000	0.141	**married**	0.261	0.009	62.84
city	0.178	0.039	0.071	**village**	0.593	0.000	142.70
decibel	0.021	0.000	0.008	**city**	-0.295	0.079	-70.89
street	0.221	0.003	0088	**streetXcity**	0.393	0.029	94.44
apart	-0.127	0.106	-0.050	**noiseXcity**	0.644	0.000	154.93
				higher	0.534	0.001	128.37
Pseudo R^2			0.054	**Adjusted R^2**			0.145
N			1,495				697
Log-likelihood			-977.1				-1,113.1
Log-likelihood of D-H model							-2,090.2

Estimates of expected value of WTP per month for a reduction of noise level by 10 dB from 70 dB to 60 dB (CZK, 2010)

	N	Mean	95 % confidence interval		Mean WTP/1dB
Non-parametric estimates					
WTP	1495	109.34	89.62	129.07	**10.93**
WTP.noise	86	152.79	117.67	187.91	**15.28**
Double-Hurdle model					
Pr(D=1|Z)	1495	0.464	0.438	0.490	-
E(WTP|X, WTP>0)	697	240.48	177.68	328.03	**24.05**
E(WTP|X)	1495	109.42	77.80	160.63	**10.94**
Double-Hurdle model: households exposed to noise above 70 dB					
Pr(D=1|Z)	86	0.556	0.516	0.596	-
E(WTP|X, WTP>0)	60	374.62	251.51	563.45	**37.46**
E(WTP|X,Z)	86	223.21	150.00	290.63	**22.32**

Social benefits from a reduction of noise level (mil. CZK per month, 2010)

dB	L_{dvn}	D-H	N	D-H (mil. CZK)			N (mil. CZK)		
		Mean WTP/1dB		*Mean*	*95 % conf. inter.*		*Mean*	*95 % conf. inter*	
		CZK per month			*LL*	*UL*		*LL*	*UL*
55-59	1 022 200	10.94	10.93	27.96	19.88	41.05	27.94	22.90	27.96
60-64	671 600	22.32	15.28	112.43	75.55	146.39	76.96	59.27	112.43
65-69	367 400	22.32	15.28	102.51	68.89	133.47	70.17	54.04	102.51
70-74	178 200	22.32	15.28	69.61	46.78	90.63	47.65	36.70	69.61
>75	48 500	22.32	15.28	24.36	16.37	31.71	16.67	12.84	24.36
Total	2 287 900	-	-	**336.87**	**227.47**	**443.25**	**239.39**	**185.75**	**336.87**
Notes: N – non-parametric estimates, D-H - double hurdle model, LL – lower limit, UL – upper limit									

Conclusions

- Strategic noise mapping
  - Over limit for road traffic noise for L_{dvn} (70 dB(A)) $\Rightarrow$ **222,700 inhabitants**
  - Over 55 dB(A) $\Rightarrow$ **2,287,900 inhabitants**
- Reduction in road noise levels for all bands to a level of **55 dB**
- Social benefits
  - Non-parametric estimates: **239 mil. CZK**
  - Parametric estimates based on D-H model: **336 mil. CZK**
- The highest benefits of the measures are generated for the noise bandwidth
  - 60-64 dB: **76 mil. CZK** (non-parametric) / **112 mil. CZK** (D-H)
  - 65-69 dB: **70 mil. CZK** (non-parametric) / **102 mil. CZK** (D-H)

Thank You for Your Attention!

Contact:

patrik.sieber@vse.cz
jan.melichar@czp.cuni.cz