Spatial Effects in Willingness-to-Pay

The Case of Nuclear Risks

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Overview

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1. Introduction

- Nuclear power plants are associated with various risks. The most prominent are:
  - Accident risk
  - Nuclear waste disposal
- In Switzerland, mandatory liability insurance covers the financial consequences of an accident up to CHF 1 bn.
- An increase in insurance coverage reduces financial risk but increases price for electricity.
- Solving the nuclear waste problem is almost certainly also linked to higher costs and thus higher electricity prices.

1. Introduction (cont.)

- People's willingness-to-pay (WTP) for reducing these risks may vary with distance from the power plant:
  - More distance $\rightarrow$ less exposure (self insurance) $\rightarrow$ **lower** WTP
  - More distance $\rightarrow$ higher frequency of sceptical individuals (spatial sorting) $\rightarrow$ **higher** WTP

$\Rightarrow$ What is the net effect of distance on the WTP
  - for reducing financial consequences of an accident?
  - for solving the waste disposal problem?

2. Literature

Property value approach: Negative externality emanating from nuclear power plants affects equilibrium prices in housing and property markets.

- Three Mile Island (Nelson, 1981; Gamble and Downing, 1982): Weak or reversed distance effect on property values.
- Folland and Hough (2000): Negative impact of nuclear power plants on land prices. Effect of distance is ambiguous.
- Nuclear waste shipment (Gawande and Jenkins-Smith, 2001): Average house value increases with distance from shipment route.

2. Literature (cont.)

- Estimates of WTP from analyzing market data are potentially distorted and incomplete.

$\Rightarrow$ Experimental evidence may complement information gleaned from market data.

- Smith and Desvousges (1986): Hazardous waste: positive distance gradient of $330-$495 per mile (CV method).
- Riddel et al. (2003): Nuclear waste transportation: perceived risk decreases with distance to the *planned* route.

3. Hypotheses

1. Marginal WTP for higher liability insurance coverage (MWP_C) may decrease or increase with distance from the nearest nuclear plant.
    - Risk effect: MWP_C decreases with distance
    - Sorting effect: MWP_C increases with distance
2. Pure (negative) risk effect can be estimated, when controlling for attitude.
3. WTP for solving the waste problem (WTP_W) does not depend on distance.
4. MWP_C and WTP_W increase with income.

4. Experimental Design

391 persons living in the German-speaking part of Switzerland were interviewed during September and October 2001.

- Method: Stated Choice Experiment (SCE) (McFadden, 1974; Louvière and Hensher, 1982).
- Individuals chose among two different types of electricity.
- Each type of electricity was described by 5 attributes: X=(PRICE,BLACKOUT,WASTE,DAMAGE,COVERAGE).

4. Experimental Design (cont.)

Decision No. 4209		
	Type A power	**Type B power**
Price	A kilowatthour costs the same as today	A kilowatthour is 60 percent more expensive than today
Blackouts	2 blackouts per year on average	2 blackouts per year on average
Waste	There are unresolved problems with waste disposal	There are no unresolved problems with waste disposal

4. Experimental Design (cont.)

Damage	A large scale accident can cause losses up to a maximum of Swiss francs 200 bn. (This amounts to Swiss francs 70,000 per household on average)	A large scale accident can cause losses up to a maximum of Swiss francs 100 mn. (This amounts to Swiss francs 35 per household on average)
Insurance Coverage	1 percent of this maximum damage is covered	100 percent of this maximum damage is covered
Your Choice	☐ Type A	☐ Type B
	☐ cannot decide	

4. Experimental Design (cont.)

- Each individual made 14 such choices.
- Attribute levels included:

Attribute	Levels (Coding)	Unit	Status quo
price	0; 10; 30; 60 (0;...;60)	percent increase	0
blackout	2; 14 (0;1)	number/year	2
waste	unresolved problems (1)	-	unresolved
	no unresolved problems (0)		problems
damage[a]	0.1; 10; 100; 200 (0.1;...;200)	CHF bn.	200
coverage[b]	1; 20; 50; 100 (0;...;100)	percent	1

a) Maximum loss in US$ per household: 21; 2,100;21,000;42,000 (at 2002 exchange rates)

b) Nuclear insurance coverage in percent of loss

4. Experimental Design (cont.)

Other variables:

- DISTANCE: respondent's distance in km to the nearest nuclear power plant.
- PESSIMIST = 1 if respondent considered a nuclear accident at least ten times more probable than experts.
- OPPONENT = 1 if respondent said to be against nuclear energy even if there was no waste disposal problem.
- SEXM = 1 if respondent is male.
- INCOME: yearly income in CHF. Seven categories were used in the questionnaire. 44 percent declined to reveal their income (INC_MSSG=1).

5. Econometric Specification

- Individuals choose between status quo and an alternative type of electricity.
  - V_{im}: Respondent i's utility of the status quo
  - V_{ij}: Respondent i's utility of the alternative in choice situation j

$$\begin{aligned} V_{ij} = &\beta_0 + \beta_1 \text{COVERAGE}_j + \beta_2 \text{NOWASTE}_j + \beta_3 \text{BLACKOUT}_j \\ &+ \beta_4 \text{DAMAGE}_j + \beta_5 \text{OUTLAY}_j + \beta_6 \text{OUTLAY}_j^2 \\ &+ \beta_7 \text{DIST}_i \cdot \text{COVERAGE}_j + \beta_8 \text{DIST}_i \cdot \text{NOWASTE}_j \\ &+ \ldots + \nu_i + \epsilon_{ij} \end{aligned}$$

5. Econometric Specification (cont.)

- $y_i = 1$ if respondent chose the alternative, i.e. $y_i = 1$ if $V_{ij} - V_{im} > 0$.
- Random effects probit model estimated using maximum likelihood.
- Estimated utility function $\hat{V}$ permits to calculate WTP for product attributes:

$$MWP_C := -\frac{\partial \hat{V} / \partial \text{COVERAGE}}{\partial \hat{V} / \partial \text{OUTLAY}}$$

$$WTP_W := -\frac{\hat{V}[\text{NOWASTE} = 1] - \hat{V}[\text{NOWASTE} = 0]}{\partial \hat{V} / \partial \text{OUTLAY}}$$

	Sign[b)]		Coefficient		Std.Err.	z
COVERAGE	+	β_1	0.009887	***	0.002264	4.37
NOWASTE	+	β_2	0.516774	***	0.168756	3.06
BLACKOUT	-	β_3	-0.362759	***	0.049799	-7.28
DAMAGE	-	β_4	0.001445		0.000939	1.54
OUTLAY	-	β_5	-0.003341	***	0.000303	-11.04
OUTLAY2	+	β_6	1.19E-7	***	0.000000	11.06
DIST·COVERAGE	-	β_7	-1.03E-4	**	0.000042	-2.47
DIST·NOWASTE	0	β_8	-0.001138		0.003068	-0.37
DIST·SEXM·COVERAGE	?	β_{10}	1.54E-4	***	0.000044	3.47
DIST·SEXM·NOWASTE	0	β_{11}	0.005323		0.003347	1.59
DIST·PESS·COVERAGE	+	β_{13}	1.22E-4	**	0.000049	2.49
DIST·PESS·NOWASTE	0	β_{14}	-0.004200		0.003589	-1.17
DIST·OPP·COVERAGE	+	β_{16}	-0.77E-4		0.000060	-1.29
DIST·OPP·NOWASTE	0	β_{17}	0.002981		0.004520	0.66
SEXM·COVERAGE	-	β_{22}	-0.008248	***	0.002285	-3.61
SEXM·NOWASTE	-	β_{23}	-0.427121	**	0.173976	-2.46
PESS·COVERAGE	+	β_{25}	-0.005563	**	0.002417	-2.30
PESS·NOWASTE	?	β_{26}	0.285538		0.181611	1.57
OPP·COVERAGE	+	β_{28}	0.003360		0.003009	1.12
OPP·NOWASTE	+	β_{29}	0.273641		0.224882	1.22
INCOME·OUTLAY	+	β_{34}	7.19E-009	***	0.000000	2.52
Log likelihood = -2,178.2026, N=4,613, 376 respondents						

a) Estimation for the full equation (containing 37 rather than 21 explanatory variables) are given in the appendix.
b) Theoretically expected sign.

6. Results

General:

- All product attributes show plausible signs and relative magnitudes, except for DAMAGE.
- Women value both additional insurance coverage and solving the waste disposal problem more than men.
- Pessimists are willing to pay *less* for coverage than non-pessimists
- Pessimists are willing to pay *more* for solving the waste disposal problem than non-pessimists.

$\Rightarrow$ Pessimists care more about non-financial risks.

6. Results (cont.)

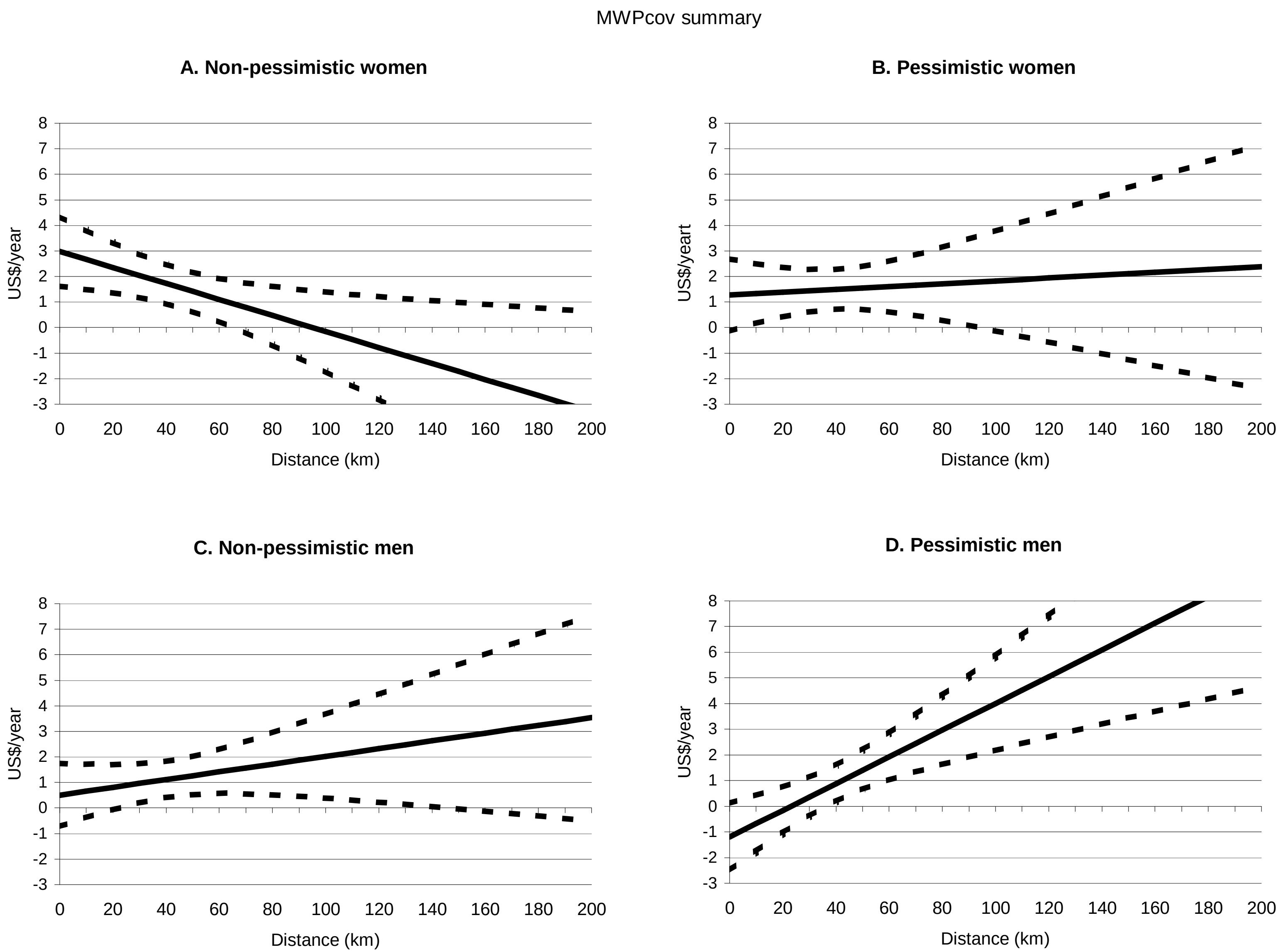
Distance:

- DISTANCE reduces WTP for coverage (MWP_C) $\rightarrow$ Hypothesis (2), confirmed.
- DISTANCE is immaterial for WTP to solve the waste problem (WTP_W) $\rightarrow$ Hypothesis (3), confirmed.
- WTP decreases with income $\rightarrow$ Hypothesis (4), confirmed.
- PESSIMIST and SEXM counterbalance the effect on MWP_C $\rightarrow$ Hypothesis (1), confirmed.

6. Results (cont.)

- Pure risk-effect: non-pessimistic women not opposed to nuclear energy: SEXM=0, PESSIMIST=0, OPPONENT=0

6. Results (cont.)



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6. Results (cont.)

Lifetime WTP calculated at median sample values:

- WTP_W: $1,090
- Full coverage at distance=35 km: $1,440
- Full coverage at distance=0 km: $2,280
- Distance gradient: $24 per km

7. Conclusions

- Distance does not have a significant effect on MWP_C on average, in keeping with U.S. findings based on property prices.
- But: Controlling for attitudinal variables (and hence the sorting effect) reveals a significant negative effect of distance.
- Estimated effects are by one order of magnitude smaller than those reported from U.S. (survey) studies.
- Experimental evidence data complements market data by focussing on preferences rather than equilibrium prices.

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