Cost-Benefit Analysis and Transportation Noise

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Framing Questions

- **Q1**: What is the state of the art in noise damage valuation that could potentially be applied to CBA of noise mitigation efforts?
- **Q2**: What additional research needs to be done on noise damage valuation?
- **Q3**: What is the applicability of damage estimates by location or mode of transportation? (Benefits transfer issue.)

Economic Concepts

- Damage valuation methods for environmental pollutants & nuisances, such as noise: **Revealed Preference** methods (market values) & **Stated Preference** methods (choice surveys).
- Range of damage estimates in dollars: **Noise Depreciation Index** for housing values & **Willingness to Pay** (WTP) values for nuisance avoidance (demand schedule for quietude).
- Validity of damage estimates in different contexts: **Benefits Transfer** by location or mode.
- **Meta-Analysis** – quantitative study of studies.

Revealed Preference Methods

- **Q**: What private market activities are **complementary** to nuisance avoidance or mitigation, where actual behavior can be observed and measured?
- **A1**: Choice of a dwelling & private willingness to pay for a house or apartment with a quieter environment (**hedonic property value method**); wage rates (aka compensating differentials).
- **A2**: Private willingness to expend resources on nuisance avoidance & mitigation, e.g., sound proofing, medical expenditures (defensive or adverting expenditure method, cost of illness method).
- **A3**: Private willingness to travel to avoid a nuisance or take advantage of a higher quality site, activity, or mode, e.g., recreation choices, route selection, modal choice (travel cost method).

Hedonic Price (HP) Method

- Uses a **sample of real estate values** & regression analysis to determine the discount (premium) associated with transportation noise (quiet); also apartment rents.
- **Study design**: with/without or before/after or combination.
- Numerous U.S. and Canadian studies for aircraft noise (30+ airport studies); fewer for road traffic noise (15+); a few railroad noise studies (5+). Some studies look only at net effects.
- **Advantages**: (1) Uses actual market behavior where individuals spend real dollars & resources; (2) not subject to numerous survey biases; (3) damage values are reasonably robust.
- **Disadvantages**: (1) Not entirely clear what is being perceived & valued (noise annoyance, safety, air pollution, visual, costs of moving); (2) choice bundle is complex, e.g., access; (3) context dependent, i.e., housing market characteristics matter.

Noise Depreciation Index (NDI)

- Imagine two identical houses: one is located close to a busy highway (65 dB) and the **comparable** house is located in an ambient noise zone (55 dB).
- Noisy house is valued on the real estate market at $180,000 and the quiet house is valued at $200,000. **Capitalized discount** (premium) is $2000 per dB, reflecting expected annoyance for some time horizon.
- **NDI** = ($2000/$200,000) = 1% per dB.
- Regression analysis is used to unbundle heterogeneous housing prices to calculate the NDI.
- *House Prices = F(Structure, Location, Environment*).
- **Location Variables**: Neighborhood & Accessibility.

NDI Values for Aircraft & Traffic

- **Aircraft Noise**: Nelson (2004) -- **meta-analysis** of 33 HP estimates for 23 airports in Canada & U.S. – wt. mean NDI of 0.7% per dB (range is 0.3% to 1.5%).
- **Traffic Noise**: Nelson (1982) – **meta-analysis** of 17 HP estimates for U.S. & Canada – mean NDI of 0.4% per dB (range is 0.2% to 0.6%). See FHWA, **1997 Highway Cost Allocation Study** for application.
- Other Traffic Noise surveys: Bertrand (1997), 0.6%.
- Theory suggests that the NDI might increase over time to reflect rising real incomes or is higher in high income areas. Better evidence needs to be assembled on this point for CBA.

Calculating a WTP value

- Suppose that noise is a "**localized**" nuisance, so that mitigation efforts affect a small portion of the total housing market in an area.
- Theory shows that an NDI can be interpreted as marginal willingness to pay (WTP) value for small changes in noise exposure (a movement along a given demand schedule).
- Each NDI is a **capitalized** value – suppose the NDI is 0.5% per dB; ave. dwelling price is $150,000; real discount rate is 5%; and useful life is 30 yrs. An NDI of $750 per dB is equal to an **annual WTP** of ca. $50 per dB per **household** (annuity factor of 0.065).
- Saelensminde & Veisten (2006) and FEHRL (2006): **CBA manual** & spreadsheet for quieter pavements for use of a WTP; Nijland et al (2003) and Haling & Cohen (1996) for CBA of noise abatement.

HP Research Needs

- **Aircraft Noise** – larger no. of existing U.S. and non-U.S. studies, so research bar is now set fairly high:
  -- Spatial error models (Cohen & Coughlin, 2006);
  -- Housing market imperfections (Pope, 2006);
  -- Identification of WTP schedule (Day et al, 2006);
  -- Nonlinear NDI & WTP (Cohen & Coughlin, 2005).
- **Traffic Noise** – **few (no?) major U.S. studies after 1980s**:
  -- Meta-analysis of existing studies (e.g., Nelson, 1982);
  -- Repeat sales analyses (Palmquist, 1982, 1992);
  -- More technical studies for major urban areas (Bateman et al, 2004; Day et al, 2006);
  -- Trade-off with accessibility (Day et al, 2003);
  -- Using annoyance indices, not dB or DNL (Baranzini, 2006).

Stated Preference (SP) Methods

- Stated Preference methods offer a direct survey approach to estimating willingness to pay for a non-market **public good** through a hypothetical or constructed market.
- Many variations depending on the (1) no. of choice dimensions; and (2) type of **payment vehicle** (open-ended, bounded, bidding game, referendum).
- **Contingent Valuation** (CV), Contingent Rankings, Contingent Ratings, Conjoint Analysis, Paired Comparisons, Choice Experiments, etc. – hundreds of survey studies exist, but only one for noise in U.S.

Examples of Survey Questions

- How much more would you be willing to pay for a comparable house or apartment if located in a quiet area, rather than close to the airport or under the flightpath? (Feitelson et al, 1996 for **Dallas-Ft. Worth Airport**)
- How much would you be willing to pay in higher apartment rents (or higher taxes) if a noise mitigation program could reduce your noise exposure by 50%? (Soguel, 1996; Pommerehne, 1988)
- How much would you be willing to pay for daytime noise to be reduced from workday levels to that of a Sunday morning? (Barreiro et al, 2005)
- How much would you be willing to pay to eliminate noise annoyance indoors? (Navrud, 2000; Bjorner, 2004)

Survey Format

- Set of attitudinal questions about the public good to be valued & factors that drive respondents' attitudes & behaviors.
- Description of the commodity or policy change to be valued; construction of a hypothetical market scenario, including a **payment vehicle** & institutional details on supplier, etc.
- Eliciting monetary values for WTP for quiet.
- Questions about socio-economic & demographic characteristics of respondents.
- Analysis and estimation of a **WTP function** for a public good (price as dependent variable).

SP Advantages & Disadvantages

- **Advantages**: (1) Very flexible, context can be controlled; (2) ex ante & ex post policy changes can be valued; (3) strong link with preferences.
- **Disadvantages –** Choice surveys are subject to several well-known biases:

  -- Hypothetical bias (protest responses, zeros, DK);

  -- Strategic bias (free-rider problem);

  -- Scope/Embedding bias (WTP should be size dependent/partial-whole effects)

  -- Anchoring bias (starting point bias);

  -- Information/Framing bias (question order/context).
- **European Results** (HEATCO)– substantial variation

SP Research Needs

- There appears to be only one SP study for the U.S. that deals with transportation noise:

-- Feitelson et al (1996) conduct a SP survey at **DFW Airport**. NDI = 1.5% per dB for houses and 0.9% per dB for apartments. Damages rise sharply at 70 DNL. Several European SP airport studies.

- More SP studies of road traffic in Europe (10+); e.g., Bjorner (2004) for Copenhagen & quieter road surface. At 65 dB, the WTP from a CV survey is 6 EUR per dB per year and the WTP from a HP study is 14 EUR per dB per year. One SP study for rail.
- **More SP studies for the U.S. are needed.**

Benefits Transfer Techniques

- **Benefits Transfer** is the general problem of using a WTP value from a given study area (mode) for a policy evaluation at another location or site (or mode). CBA "best practices" include:
- **(1) Unit Value Transfer**

  -- Simple Unit Transfer for WTP (e.g., select best value based on comparable location, mode, & magnitude); point, mean, range.

  -- Unit Transfer with income or price adjustments.
- **(2) Function Transfer**

  -- Benefit Function Transfer; need to have the WTP demand function (harder for HP studies).

  -- Meta-Analysis (e.g., Nelson, 1980, 1982, 2004), but most meta-analyses are not well designed for policy use.
- **Measurement Issues** – should WTP be expressed on a $ per dB basis or $ for levels of annoyance with a separate transfer function for annoyance into dB (Schultz Curve)?
- **Standardized Values** (e.g., Europe; VOT & VSL).

THANK YOU.

QUESTIONS?

- Copies of the Presentation
- Copies of my Survey Paper
- Email: JPN@PSU.EDU