Hedonic Prices

- Goods are valued for the utility bearing attributes. Example: housing
- A house has bathrooms, bedrooms, living rooms, garden, garage, etc.

Price of a house:
Price of a bathroom $\times$ No. of bathrooms
$+$ Price of a bedroom$\times$ No. of bedrooms
$+$ Price of a living room $\times$ No. of living rooms
$+$ Price of a garage $\times$ No. of garages
$+$ Price of a garden
$+$ Price of proximity to school$\times$ promixity of school
$+$ Price of school quality $\times$ school quality

Price of a computer

$=$ Price of a hard drive

$+$ Price of a monitor

$+$ Price of a chip$\times$ No. of chips

$+$ Price of a DVD drive $\times$ No. of DVD drives

- If we analyze the price of houses this way, then even though each house is different from another, we can get some sense of how housing prices are determined.
- Why do we need to decompose them? It is important to know how much consumers value each items.
- What is the value of having a good school? Important for policy makers to know.
- How should be the value of new goods, such as computers with different features?

Even though the price of a house is the sum of the prices of attributes, only the total price is observable.
How do we get to know the price of each of its components?

Outline of the Theoretical Framework

Example: housing

Consumers

Utility: $U(z, x, \alpha)$

- z: m characteristics: No. of living rooms, No. of bathrooms, garden, etc.
- $z = (z_1, z_2, ..., z_m)$
- x: numeraire commodity
- α: variables characterizing individual consumers (No. of children, etc.)

Budget constraint: $y = p(z) + x$

- y: income
- $p(z)$: price of a good that has characteristics z. For example, price of a house which has 2 bedrooms $z_1 = 2$, 3 bathrooms $z_2 = 3$.

Price of a characteristic:

$$\frac{\partial p(z)}{\partial z_i} = p_i()$$

Suppose a house has one bedroom more than the other one, and everything else is the same, and the house is \$1,000 more expensive than the other house. Then, the price of an additional bedroom is \$1,000.

$F(y, \alpha)$: joint distribution of y and α
Suppose that $p_x = 1$
F.O.C. of consumer's problem:choose the vector of characteristics z such that

$$\frac{\partial p(z)}{\partial z_i} = p_i(z) = \frac{U_{z_i}(z, y - p(z), \alpha)}{U_x(z, y - p(z), \alpha)}$$
$$\equiv h(z, y - p(z), \alpha)$$

Producers:

Cost Function: $C(M, z, \beta)$

- M Number of units
- β: Variables characterizing producer characteristics.

$G(\beta)$: distribution of producer characteristics.
Profit: $p(z)M - C(M, z, \beta)$

F.O.C. for profit maximization:

$$\begin{aligned} Z &: \quad p_z = \frac{C_z(M, z, \beta)}{M} \\ M &: \quad p(z) = C_M(M, z, \beta) \end{aligned}$$

Equilibrium

- Demand: $D(z) = \int I\left(z^d(y, \alpha, p) = z\right) dF(\alpha)$ where $z^d(y, \alpha, p)$ is the consumer optimal choice of characteristics.
- Suppply: $S(z) = \int M(z, \beta, p) I(z^s(\beta, p) = z) dG(\beta)$ where $M()$ is the producer optimal unit of output and $z^s()$ is the producer's optimal choice of characteristics.

- At equilibrium demand equals supply.
- $p(z)$ is set such that $D(z) = S(z)$
- Market matches individuals whose choice is a product with characteristics z to its producer.

How should we estimate the hedonic prices, together with the parameters of the consumers and producers? Solving the equilibrium of the model is expected to be extremely difficult.

Rosen's 2 Step Approach

Step 1 Estimate the price equation $p(z)$ which is a function of product characteristics alone. That is, estimate the market equilibrium price using OLS.

$$p(z) = \gamma + \psi z + z' \pi z + \eta$$

where η: error term.
$\hat{p}(z) = \hat{\gamma} + \hat{\psi} z + z' \hat{\pi} z$: estimated price equation.

step 2 Estimate demand and supply equation by using the price of each characteristics, which is

$$\frac{\partial \hat{p}(z)}{z_i} = \hat{\psi} + 2\hat{\pi} z_i$$

- Demand side equation: linearized version of the consumer choice equation (F.O.C.)

$$\frac{\partial \hat{p}(z)}{z_i} = \hat{\psi} + 2\hat{\pi} z_i = b_{0i} + b_{1i} z + b_{2i} x + b_{3i} \alpha + v_{1i}$$

  v_{1i}: demand equation error term

- Supply side equation: linearized version of the F.O.C. of firm's profit maximization (set $M = 1$)

$$\frac{\partial \hat{p}(z)}{z_i} = \hat{\psi} + 2\hat{\pi} z_i = c_{0i} + c_{1i} z + c_{2i} \beta + v_{2i}$$

  v_{2i}: supply equation error term

- Estimate demand and supply equations using OLS. Or 2SLS where demand shifter is used as IV's for supply equation and vice versa.

Epple (1987), Bartik (1987)

Criticize the Rosen's approach:

- Simple OLS or IV gives us biased estimates of the demand equation because of the nonlinearities of the estimated price equation $p(z)$
- By choosing optimal characteristics z, a consumer is both choosing z and the price $\frac{\partial p(z)}{\partial z}$ at the same time.
- Hence, the error term of the demand equation v_{1i} and the RHS variable z_i is likely to be correlated.

Example:

Models with linear demand and supply functions. K distinct markets.

- Hedonic Price Equation:

$$p_k = \gamma_k + \psi_k z_k + \frac{z_k' \pi z_k}{2} + \zeta_k$$

- Demand and Supply Functions:
  Demand: $\frac{\partial p_k}{\partial z_k} = A_1 z_k + H_1 x_{1k} + v_{1k}$
  Supply: $\frac{\partial p_k}{\partial z_k} = A_2 z_k + H_2 x_{2k} + v_{2k}$
  $x_{1k} \equiv (\alpha, y - p(z))$, $x_{2k} = \beta$

$$z_k = (\pi_k - A_1)^{-1} (H_1 x_{1k} + v_{1k} - \psi_k)$$

- OLS applied to the demand and supply equation is not unbiased. Simultaneous equation bias.
- If ζ_k is correlated with v_{1k}, then OLS for the hedonic price equation is not unbiased.
- Treating all elements of (x_{1k}, x_{2k}) as exogenous (i.e. uncorrelated with ζ_k, v_{1k}, v_{2k}) is not consistent with the structure of the model.
  From demand and supply,

$$(\pi_k - A_1)^{-1} (H_1 x_{1k} + v_{1k} - \psi_k) = (\pi_k - A_2)^{-1} (H_2 x_{2k} + v_{2k} - \psi_k)$$

At least one of the (x_{1k}, x_{2k}) has to be correlated with the error term.

- This is because consumers try to look for the housing characteristics that they prefer. Thus, they also try to look for producer characteristics that matches them well.
- Example: Suppose the landlords who are carpenters maintain houses better (supply traits). Individuals who prefer well maintained houses (demand traits) choose houses whose landlords are carpenters. Market matches supply traits and demand traits.

Epple (1987) discusses identification conditions.

Bartik (1987) discusses instrumental variable estimation.

- Income: Consumer tastes and z are correlated because taste shifts changes z as well, resulting in bias. Income is correlated with z but not correlated with tastes.
- City dummy. Cities have different equilibrium price equation because distribution of (observed) demand and supply characteristics (x_{1k}, x_{2k}) are different across different cities. Since preference and production parameters are the same, but the prices are different, city dummies are correlated with z but not correlated with the error term of the demand.
  Example: Cities whose population are mostly single have higher prices for houses that are close to bars.

Empirical Example:

- z: physical condition of the neighborhood near a house.
- x_{1k}: Demand characteristics: log(non housing expenditure), household size, age of household head, age squared, black head of household, hispanic head of household, female head of household.
- Supply of z is fixed.

Estimation Results of the Demand Equation

variable	OLS (t)		2SLS (t)	
Physical condition	-0.001	(-0.05)	-1.065	(-9.05)
log(Nonhousing expenditure)	0.05	(1.62)	0.69	(7.23)
Household size	0.034	(2.88)	-0.116	(-3.50)
Age of household head	0.015	(2.17)	0.020	(1.19)
Age Squared	-2.1E-4	(-2.75)	-1.3E-4	(-0.68)
Black head	0.061	(1.13)	-1.16	(-6.09)
Hispanic head	-0.70	(-14.46)	-0.97	(-7.68)
Female head	0.17	(4.58)	0.28	(2.95)

Individuals who value physical conditions are going to purchase more of them. Error term positively correlated with z. Positive bias on the physical condition term.