

In the Matter of: Entergy Nuclear Operations, Inc.
(Indian Point Nuclear Generating Units 2 and 3)



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COST-BENEFIT ANALYSIS

Concepts and Practice

Anthony E. Boardman

University of British Columbia

David H. Greenberg

University of Maryland Baltimore County

Aidan R. Vining

Simon Fraser University

David L. Weimer

University of Wisconsin–Madison



Upper Saddle River, New Jersey 07458

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announcement of a new program or policy. The main advantage of using stock prices is that new information concerning policy changes is quickly and efficiently capitalized into stock prices. Changes in stock prices provide an unbiased estimate of the value of a policy change to shareholders. Also, stock price data are readily accessible in computer-readable form.

In an event study, researchers estimate the *abnormal return* to a security, which is the difference between the return to a security in the presence of an event and the return to the security in the absence of the event. Usually, researchers estimate daily abnormal returns during an *event window*, that is, for the period during which the event is assumed to affect stock prices—often a few days. Because the return to the security in the absence of the event is unobservable, it is inferred from changes in the prices of other stocks in the market, such as the Dow Jones Index or the FTSE 100.¹¹ The estimated daily abnormal returns during the event window can be aggregated to obtain the *cumulative abnormal return*, which measures the total return to shareholders that can be attributed to the event. Cumulative abnormal returns provide an estimate of the change in producer surplus due to some new policy.

PROBLEMS WITH SIMPLE VALUATION METHODS

The valuation methods discussed earlier in this chapter have several potential limitations, many of which were discussed earlier. This section focuses on the *omitted variable* problem and *self-selection* bias.

The Omitted Variable Problem

All of the methods discussed thus far in this chapter implicitly assume that all other explanatory variables are held constant, but this is unlikely in practice. Consider, for example, using the intermediate good method to value irrigation. Ideally, analysts would compare the incomes of farmers if the irrigation project were built with the incomes of the same farmers if the project were not built. In practice, if the project is built, analysts cannot directly observe what the farmers' incomes would have been if it had not been built. One way to infer what their incomes would have been without the project is to use the incomes of the same farmers before the project was built (a before and after design) or the incomes of similar farmers who did not benefit from an irrigation project (a non-experimental comparison group design). The before and after design is reasonable only if all other variables that affect farmers' incomes remain constant, such as weather conditions, crop choices, taxes, and subsidies. If these variables change then the incomes observed before the project are not good estimates of what incomes would have been if the project had not been implemented. Similarly, the comparison group design is appropriate only if the comparison group is similar in all important respects to the farmers with irrigation, except for the presence of irrigation.

As mentioned in Exhibit 13-2, salary differences between those with a college degree and those with a high school degree may depend on ability, intelligence, socioeconomic background and other factors in addition to college attendance. Similarly, in labor market studies of the value of life, differences in wages among jobs may depend on variations in status among jobs and the bargaining power of different unions in

addition to fatality risk. In simple asset price studies, the price of a house typically depends on factors such as its distance from the central business district and size, as well as whether it has a view. Analysts should take account of all important explanatory variables. If a relevant explanatory variable is omitted from the model and if it is correlated with the included variable(s) of interest, then the estimated coefficients will be biased, as discussed in Chapter 12.

Self-Selection Bias

Another potential problem is self-selection bias. Risk-seeking people tend to self-select themselves for dangerous jobs. Because they like to take risks they may be willing to accept low salaries in quite risky jobs. Consequently, we may observe only a very small wage premium for dangerous jobs. Because risk seekers are not representative of society as a whole, the observed wage differential may underestimate the amount that average members of society would be willing to pay to reduce risks and, hence, may lead to underestimation of the value of a statistical life.

The self-selection problem arises whenever different people attach different values to particular attributes. As another example, suppose we want to use differences in house prices to estimate a shadow price for noise. People who are not adverse to noise, possibly because of hearing disabilities, naturally tend to move into noisy neighborhoods. As a result, the price differential between quiet houses and noisy houses may be quite small, which would lead to an underestimation of the shadow price of noise for the "average" person.

HEDONIC PRICING METHOD

The *hedonic pricing* method, sometimes called the *hedonic regression method*, offers a way to overcome the omitted variables problem and self-selection bias that arise in the relatively simple valuation methods discussed earlier. Most recent wage-risk studies for valuing a statistical life (also called labor market studies) apply the hedonic regression method.

Hedonic Regression

Suppose, for example, that scenic views can be scaled from 1 to 10 and that we want to estimate the benefits of improving the (quality) "level" of scenic view in an area by one unit. We could estimate the relationship between individual house prices and the level of their scenic views. But we know that the market value of houses depends on other factors, such as the size of the lot, which is probably correlated with the quality of scenic view. We also suspect that people who live in houses with good scenic views tend to value scenic views more than other people. Consequently, we would have an omitted variables problem and self-selection bias.

The hedonic pricing method attempts to overcome both of these types of problems.¹² It consists of two steps. The first estimates the effect of a marginally better scenic view on the value (price) of houses, a slope parameter in a regression model, while controlling for other variables that affect house prices. The second step estimates the willingness-to-pay for scenic views, after controlling for "tastes," which are proxied

by income and other socioeconomic factors. From this information, we can calculate the change in consumer surplus resulting from projects that improve or worsen the views from some houses.

The hedonic pricing method can be used to value an attribute, or a change in an attribute, whenever its value is capitalized into the price of an asset, such as houses or salaries. The first step estimates the relationship between the price of an asset and all of the *attributes* (characteristics) that affect its value.¹³ The price of a house, P , for example, depends on such attributes as the quality of its scenic view, $VIEW$, its distance from the central business district, CBD , its lot size, $SIZE$, and various characteristics of its neighborhood, $NBHD$, such as school quality. A model of the factors affecting house prices can be written as follows:

$$P = f(CBD, SIZE, VIEW, NBHD) \quad (13.2)$$

This equation is called a *hedonic price function* or *implicit price function*.¹⁴ The change in the price of a house that results from a unit change in a particular attribute (i.e., the slope) is called the *hedonic price*, *implicit price*, or *rent differential* of the attribute. In a well-functioning market, the hedonic price can naturally be interpreted as the additional cost of purchasing a house that is marginally better in terms of a particular attribute. For example, the hedonic price of scenic views, which we denote as r_v , measures the additional cost of buying a house with a slightly better (higher-level) scenic view.¹⁵ Sometimes hedonic prices are referred to as *marginal hedonic prices* or *marginal implicit prices*. Although these terms are technically more correct, we will not use them in order to make the explanation as easy to follow as possible.

Usually analysts assume the hedonic price function has a multiplicative functional form, which implies that house prices increase as the level of scenic view increases but at a decreasing rate. Assuming the hedonic pricing model represented in equation (13.2) has a multiplicative functional form, we can write:

$$P = \beta_0 CBD^{\beta_1} SIZE^{\beta_2} VIEW^{\beta_3} NBHD^{\beta_4} e^{\epsilon} \quad (13.3)$$

The parameters, β_1 , β_2 , β_3 , and β_4 , are elasticities: They measure the proportional change in house prices that results from a proportional change in the associated attribute.¹⁶ We expect $\beta_1 < 0$ because house prices decline with distance to the CBD , but β_2 , β_3 , and $\beta_4 > 0$ because house prices increase as $SIZE$, $VIEW$, and $NBHD$ increase.

The hedonic price of a particular attribute is the slope of equation (13.2) with respect to that attribute. In general, the hedonic price of an attribute may be a function of all of the variables in the hedonic price equation.¹⁷ For the multiplicative model in equation (13.3), the hedonic price of scenic views, r_v , is:¹⁸

$$r_v = \beta_3 \frac{P}{VIEW} > 0 \quad (13.4)$$

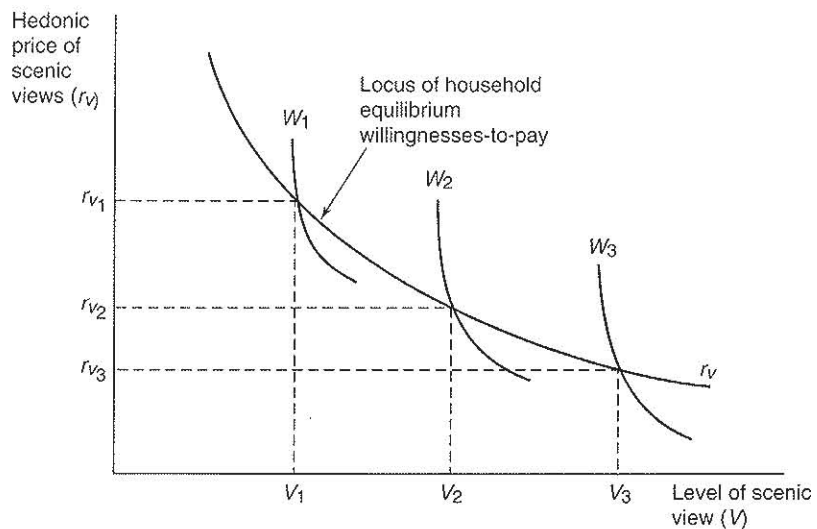
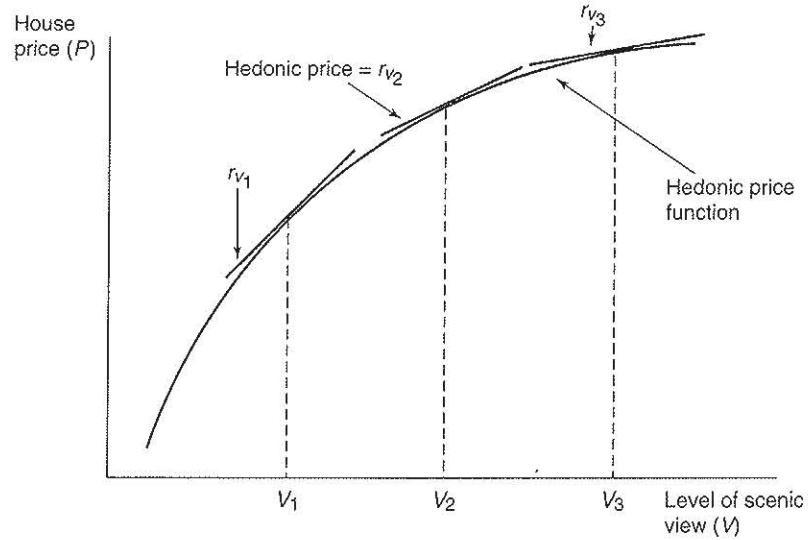
In this model, the hedonic price of scenic views depends on the value of the parameter β_3 , the price of the house, and the view from the house. Thus, it varies from one observation (house) to another. Note that plotting this hedonic price against the level of

scenic view provides a downward-sloping curve, which implies that the implicit price of scenic views declines as the level of the view increases.

The preceding points are illustrated in Figure 13-3. The top panel shows an illustrative hedonic price function with house prices increasing as the level of scenic view increases, but at a decreasing rate. The slope of this curve, which equals the hedonic price of scenic views, decreases as the level of the scenic view increases. The bottom panel shows more precisely the relationship between the hedonic price of scenic views (the slope of the curve in the top panel) and the level of scenic view.

In a well-functioning market, utility-maximizing households will purchase houses so that their willingness-to-pay for a marginal increase in a particular

FIGURE 13-3 Hedonic Price Method



(13.2)

14 The change in the contribution (i.e., the value of the attribute. In addition, as the addition of a particular attribute is measured as r_v , the marginal (per-level) scenic view hedonic prices of scenic views, we will not observe a change in the hedonic price of scenic views as the level of scenic view increases but the slope of the hedonic price function increases as the level of scenic view increases.

(13.3)

proportional change in the value of the attribute.¹⁶ We can estimate the willingness to pay for a marginal increase in the level of scenic view by using the hedonic price function in equation (13.2) with the following assumptions:

(13.4)

of the parameter β_3 from one observation against the level of scenic view.

attribute equals its hedonic price. Consequently, in equilibrium, the hedonic price of an attribute can be interpreted as the willingness of households to pay for a marginal increase in that attribute. The graph of the hedonic price of scenic views, r_v , against the level of scenic view is shown in the lower panel of Figure 13-3. Assuming all households have identical incomes and tastes, this curve can be interpreted as a household inverse demand curve for scenic views.

Yet, households differ in their incomes and taste. Some are willing to pay a considerable amount of money for a scenic view; others are not. This brings us to the second step of the hedonic pricing method. To account for different incomes and tastes, analysts should estimate the following willingness-to-pay function (inverse demand curve) for scenic views:¹⁹

$$r_v = W(\text{VIEW}, Y, Z) \quad (13.5)$$

where r_v is estimated from equation (13.4), Y is household income, and Z is a vector of household characteristics that reflects tastes (e.g., socioeconomic background, race, age, and family size). Three willingness-to-pay functions, denoted W_1 , W_2 , and W_3 , for three different types of households are drawn in the lower panel of Figure 13-3.²⁰ Equilibria occur where these functions intersect the r_v function. Thus, when incomes and socioeconomic characteristics differ, the r_v function is the locus of household equilibrium willingnesses-to-pay for scenic views.

Using the methods described in Chapter 4, it is straightforward to use equation (13.5) to calculate the change in consumer surplus to a household due to a change in the level of scenic view. These changes in individual household consumer surplus can be aggregated across all households to obtain the total change in consumer surplus.

Using Hedonic Models to Determine the VSL

The simple forms of consumer purchase and labor market studies to value life that we described previously may result in biased estimates due to omitted variables or self-selection problems. For example, labor market studies to value life that examine *fatal risk* (the risk of death) often omit potentially relevant variables such as *injury risk* (the risk of nonfatal injury). This problem may be reduced by using the hedonic pricing method. For example, a researcher might estimate the following nonlinear regression model to find the hedonic price of fatality risk:²¹

$$\ln(\text{wage rate}) = \beta_0 + \beta_1 \ln(\text{fatality risk}) + \beta_2 \ln(\text{injury risk}) + \beta_3 \ln(\text{job tenure}) \\ + \beta_4 \ln(\text{education}) + \beta_5 \ln(\text{age}) + \epsilon \quad (13.6)$$

The inclusion of injury risk, job tenure, education, and age in the regression model controls for variables that affect wages and would bias the estimated coefficient of β_1 if they were excluded. Using the procedure demonstrated in the preceding section, the analyst can convert the estimate of β_1 to a hedonic price of fatality risk and can then estimate individuals' willingness-to-pay to avoid fatal risks. Most of the empirical estimates of the value of life that are reported in Chapter 15 are obtained from labor market and consumer product studies that employ models similar to the one presented in equation (13.6).

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