Econometric estimation of non-market values and evaluation of benefit transfer techniques

ECONOMETRIC ESTIMATION OF NON-MARKET VALUES AND EVALUATION OF BENEFIT TRANSFER TECHNIQUES

by

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ABSTRACT

This thesis presents investigations of three topics in non-market valuation; contingent valuation, hedonic property price analysis, and benefit transfer. Chapter Three presents an original analysis of contingent valuation data collected at a popular birding site in California using a heteroskedastic Tobit model. Also the distribution of willingness to pay bids is estimated using kernel density estimation. Chapter Four presents the estimation of a hedonic price function. The purpose of this study is to identify the effects of proximity to the Tanque Verde riparian corridor in Tucson Arizona on the value of homes in the area. The third topic is an analysis of benefit transfer techniques, with particular attention to the transfer of non-market benefit estimates across time. These techniques are presented and evaluated in Chapter Five.

Chapter 1

1. Introduction

This thesis applies various econometric methods to three non-market valuation techniques; the contingent valuation method (CVM), the hedonic property price method, and benefit transfer. These methods are studied in the context of riparian habitats in the arid southwest. These rare habitats have received relatively little attention in the literature.

The valuation of non-market goods is an active area of study in natural resource economics. Major academic journals frequently publish articles on new variations of non-market techniques, and tests for validity. Yet due to the costliness and difficulty of performing a high quality original non-market valuation study, there remain many uncertainties regarding accuracy, and therefore the usefulness of non-market valuation and benefit transfer techniques. This thesis adds three contributions to the understanding of these methods.

1. An original analysis of the data collected in a contingent valuation survey conducted at the Kern River Preserve in southern California.
2. An original hedonic property price analysis of the value of the Tanque Verde Wash, an ephemeral stream[1] in Tucson Arizona.
3. An evaluation of benefit transfer techniques, using the results from two additional contingent valuation studies performed at the San Pedro National Riparian Conservation Area in southern Arizona, the Kern River study, and the Tanque

[1] An ephemeral stream flows only in response to precipitation events, and is dry otherwise.

Verde hedonic study, with particular attention to testing the veracity of the temporal transfer of value estimates.

The two original non-market valuation studies contribute to the expanding collection of monetary estimates for water dependent habitats. The monetization of benefits derived from water dependent ecosystems in the arid southwest is critical knowledge for land use planning, and water management policies. The analysis of benefit transfer techniques breaks new ground in the area of temporal transfers. Transfers of value estimates can be spatial in nature, as in transfers between the Kern River and the San Pedro River. But they can also be temporal, by transferring current non-market estimates back in time, or using dated estimates as approximations for current non-market values. This thesis tests various versions of benefit transfer, using techniques from the published literature. The analysis of temporal transfer is extended to investigate the effectiveness of transfers covering various time spans.

1.2 Summary of Chapters 2-5

Chapter Two is a review of published literature on the contingent valuation method, the hedonic property price method, and benefit transfer techniques. The review is meant to familiarize the reader with the methodologies applied in this thesis, and to summarize the results of similar studies.

Chapter Three presents the Kern River contingent valuation study. The contingent valuation method uses surveys to ask respondents for estimates of how much money they would be willing to pay to insure (or avoid) a hypothetical environmental change. The chapter briefly describes the site, reviews the data and its treatment, and estimates a willingness to pay function for the preservation of the Kern River and the surrounding ecosystem. The estimated function is capable of explaining only a small amount of the total variation in stated willingness to pay values. However, most of the estimated coefficients are significant at the 5% level, and their signs correspond to expectations. Using the estimated function, the expected willingness to pay for the preservation of the Kern River, per visitor, per year, is calculated to be $73.32.

Chapter Four demonstrates another method for non-market valuation; the hedonic property price method. This chapter analyzes how the sale price of homes reveals the value of the Tanque Verde Wash. The chapter begins by describing the non-market benefits of the Tanque Verde, and possible policy implications for its valuation. Next, the large data set is described, and the regression results are presented, with particular attention to the marginal effects of each variable. The chapter concludes with two alternate approaches to value aggregation. The results of the hedonic property price analysis indicate that the expected sale price of an average home was $1,698 higher for a 1000 foot decrease in the distance to the wash. The two alternate aggregation methods resulted in total value estimates of $193,939,909 and $232,255,571.

Chapter five tests the practice of benefit transfer. This method of estimating non-market values is commonly used by public agencies, but has serious questions regarding its accuracy. The benefit transfer technique uses estimates from studies performed elsewhere as proxies of value at the site of interest, thus avoiding the time and costs of performing an original study. The chapter begins by briefly presenting the results of two additional contingent valuation studies performed in 1992 and 2001 at the San Pedro River. Using the results from these studies, and the Kern River results, spatial, temporal, and combined spatial/temporal transfers are tested. For each of the three types of transfers two methods; benefit value transfer, and benefit function transfer are tested. The benefit value method transfers mean or expected willingness to pay estimates, and the benefit function method transfers the estimated willingness to pay function. Benefit value transfers are tested using the Wilocoxon rank sum test, and a test proposed by Kirchhoff, Colby, and LaFrance (1997) that utilizes 95% confidence intervals for the expected value of the habitat per person. Benefit function transfer is also tested using Kirchhoff, Colby, and LaFrance's method, in addition a Wald test for equality of regression coefficients is used.

The tests reject all of the transfers except the temporal value transfer. Chapter Five concludes by extending the investigation of the validity of temporal value transfer, with the use of the Tanque Verde data set, which spans 15 years. With non-market value estimates for many consecutive years, it was possible to calculate success rates for temporal value transfer covering time spans of 1 to 14 years. As was expected the success rate was high for a one year value transfer, and then gradually fell as the temporal span reached eight years.

1.3 Significance of Thesis Results

This thesis contributes to the pool of non-market valuation studies, and provides new insight regarding how non-market values change over time. The results from the original non-market studies can be used directly in a cost benefit framework, or could be included in a meta-analysis which combines the results from many different studies into one model (see Rosenberger & Loomis 2000, Smith & Osborne 1996, and Smith & Huang 1995). The results from the general analysis of benefit transfer support the results from previous studies that indicate that benefit transfer is a questionable practice. Finally, the extended analysis of temporal value transfers demonstrate that non-market values are changing over time, and that the probability of success for benefit transfer depends on the time span between the original study and the time period of interest.

Chapter 2

2. Literature Review

This chapter presents a review of published literature relevant to the topics of this thesis. The sections are presented in the same order as the chapters that follow. First the contingent valuation method is reviewed, including discussions of the survey instrument, the welfare measures that are estimated, and methodological issues commonly raised with regard to this method. The next section is on the hedonic property price method. The bulk of this review is of A. Myrick Freeman's (1993) excellent chapter on the topic, and is followed by a review of recent applications of the method. Chapter 2 concludes with a discussion of benefit transfer, including justification and demands for the technique and a description of the value and function methods.

2.1 Contingent Valuation Method

2.1.1 General Description & Survey Instrument

The contingent valuation method (CVM) is a stated preference technique that is commonly used to value environmental amenities. CVM was brought into the spotlight in 1988, when it was used as a tool for assessing damages resulting from the Exxon Valdez oil spill. Since, it has been the topic of contentious debate among economist and policy makers. Some, such as Diamond and Hausman (1993) argue that CVM "does not measure an economic value that conforms with economic preference concepts" (Diamond & Hausman, 1993, p, 4) and that it should not be used in cost benefit analysis, nor in compensatory damage assessment. On the other side Carson, Flores, and Meade (2000) recognize that CVM has problems, but insist that they can be overcome with careful study design and implementation. The debate among academics has served to highlight several key issues, and improve CVM study design. What follows is a description of the elements in a CVM survey instrument and several of the validity issues commonly investigated.

A CVM study uses surveys to ask respondents about their willingness to pay (WTP), or willingness to accept payment (WTA) for a hypothetical change in a non-market good. The survey is preferably administered in person however; mail, telephone, and internet surveys have also been conducted. Prato (1998) described a few common elements that valid CVM surveys should contain. First is an informative section that provides a clear description of the resource being valued. The ability of respondents to give a reliable estimate of their value for the non-market good in question is critically dependent upon their understanding of that good. This section commonly includes photographs that depict the proposed environmental change. After the description of the resource a hypothetical payment vehicle is presented. The payment vehicle describes how funds will be raised, by whom, and the manner in which they will be spent. Common examples are increased product prices required by firms to conform with new environmental regulations, donations to nonprofit organizations that purchases land for species preservation, and additional state or federal income taxes that are used by the government to remediate some environmental condition (Portney 1994). It is important that this section be as realistic as possible, to ensure that the respondents believe that the described environmental change is a reasonable possibility that warrants their careful consideration. In addition to being plausible, Hanemann (1995) asserts that the payment vehicle should be linked directly to the provision of the commodity, and that payment is viewed as mandatory once commitment has been made. The next common element of CVM surveys is the actual elicitation of WTP or WTA values. Various formats including bidding games, open-ended questions, payment cards, and dichotomous choice (referendum) have been used for eliciting respondent's value estimate. Each format has strengths and weaknesses, with no single format emerging out as a consensus choice. This leaves the selection of valuation format as a largely subjective choice, left to the discretion of the researcher. CVM surveys follow the elicitation question with one or more debriefing questions that ask why the respondents answered the way they did (Carson, Flores, & Meade 2000). This information is critical for identifying protest bids, and other invalid responses. Finally, the CVM survey should include a section that collects information on factors that potentially effect WTP or WTA values. This data on socioeconomic variables such as age, income, education, and previous experience with and proximity to the resource in question are collected in order to estimate a WTP or a WTA function.

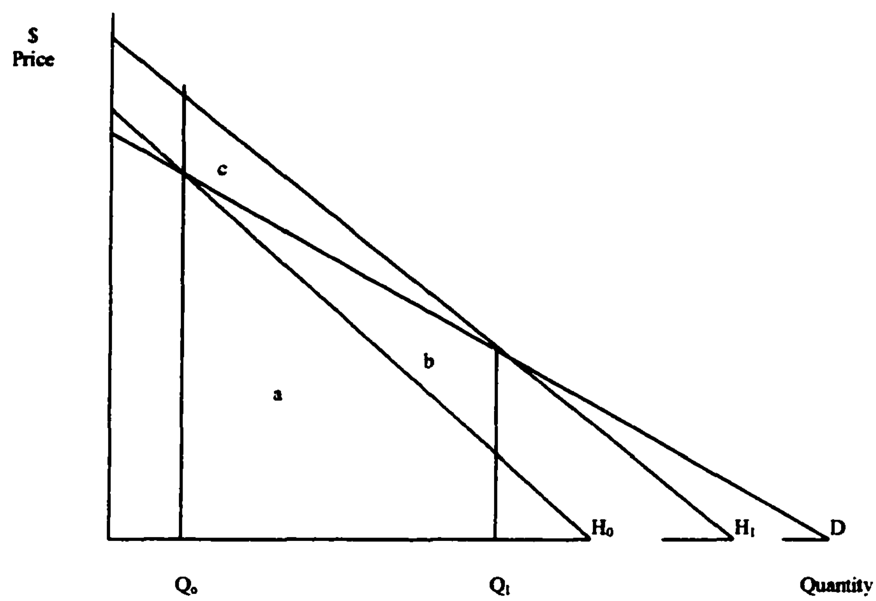
The survey instrument is refined using at least one pretest, where the CVM survey is administered to a small group who go through additional debriefing. The debriefing is designed to investigate the understandability of the survey, the believability of the hypothetical environmental change and payment vehicle, and any other factors that might bias the valuation estimate.

The final survey is administered to a statistically representative sample. Here it is important to carefully define the appropriate population. Bishop, Champ, and Mullarkey (1995) explain that if the study only deals with use values, then the appropriate sample will be limited to current and potential users of the resource. However, if non-use values such as species preservation are being studied, then the sample must be randomly drawn from an entire geographic region. Regardless of the appropriate population, a sampling strategy must be developed that will assure a sufficiently large and representative sample to support statistical inference. The final steps of a CVM study involve identification and removal of protest bids and statistical analysis of the data collected. Statistical methods are largely data specific and are not addressed in this literature review.

2.1.2 Welfare Measures

As noted in the beginning of this section a CVM survey attempts to elicit the respondent's willingness to pay (WTP) or willingness to accept payment (TWA) for a change in an environmental resource. However, WTP has become the preferred value elicitation format, partially because it produces a smaller and therefore more defensible value estimate. WTP relates to a surplus measure along a Hicksian demand curve. The Hicksian approach evaluates welfare change as the amount of money necessary to maintain a constant level of utility. Mitchell and Carson (1989) explain that when dealing with environmental goods (where the consumer is commonly constrained to consume only discrete or fixed quantities) there are two Hicksian measures of surplus. First, compensating surplus (CS) is defined as the amount of money (either positive or negative) necessary to return an individual to his original utility level after the environmental change has happened, and is represented as area 'a' in the diagram below. The second Hicksian surplus measure for an environmental good is equivalent surplus (ES). ES is the money (positive or negative) required to move an individual to the utility level that he would achieve if the environmental change takes place, and is represented by area 'a+b+c'.

Graph 2.1 Consumer Surplus Measures



D: Ordinary Marshallian curve
H_0: Hichsian demand curve for original utility level U_0
H_1: Hicksian demand curve for alternative utility level U_1
a+b equals ordinary consumer surplus
a equals compensating surplus
a+b+c equals equivalent surplus

Whether the hypothetical environmental change results in a benefit or a loss to consumers, dictates which measure, CS or ES, will be measured by a CVM survey. Bateman and Turner (1993) summarize CS and ES with the Table 2.1.

Table 2.2 CVM Surplus Measurers

Proposed change	Measure	Hicksian surplus measure for environmental good
Welfare gain	WTP to ensure that change occurs	CS
Welfare loss	WTP to avoid loss Occurring	ES

2.1.3 CVM Methodological Issues

Bateman and Turner (1993) classify CVM methodological issues into three categories: reliability, bias, and validity. Reliability is synonymous with consistency and repeatability. There are multiple forms of bias that may occur in a CVM study, many of which will be discussed below. Validity relates to weather or not a CVM study reveals the 'true' value under investigation. The authors clarify the methodological issues of CVM with following equation:

$$y = ax + b + \varepsilon$$

y = the measured value of the environmental amenity
x = the true value of the environmental amenity
a, b = constants
ε = residual error

"The reliability of the CVM instrument can be measured by e, while a and b reflect validity; the instrument being absolutely valid if a=1, b=0, and e is a random variable.

When ε is a non-random variable, a bias is likely to be present" (Bateman and Turner 1993).

Reliability is the extent to which the variance of a response is a result of random sources. The most common measurement of reliability is the estimated standard error coefficient generated from regression analysis. The standard error from a CVM regression is a result of two factors. First is variation of true WTP or WTA values. The second is variation in stated WTP or WTA, caused by inconsistent data collection methods (Mitchell and Carson 1989).

Smith and Desvousges (1986) classify bias into general, procedural, and instrument types. General biases include free riding and strategic biases where respondents do not truthfully answer valuation questions, with the expectation that misstating their true values will lead to greater future gains for themselves. Hypothetical bias is another form of general bias. Randall et al. (1983) conclude that the use of hypothetical rather than real markets can, in certain circumstances, lead to distinct bias problems. Finally, information bias is included in the general bias category. Information bias relates to the quality of the description of the environmental change being proposed (Bateman & Turner 1993). Bergrstom et. al. (1985) found strong evidence in their CVM study that additional information regarding the preservation of farmland resulted in higher WTP bids.

Procedural bias includes aggregation and interviewer bias. Aggregation bias alludes to fact that if the appropriate population is not identified then the aggregate estimate will be incorrect. The crux of the selection of population lies in weather the researcher is attempting to measure use value only, or total value which includes nonuse values that must be aggregated over regional populations (Bateman & Turner 1993). Interviewer bias was investigated by Walsh (1992). He found that socioeconomic variation across interviewers caused systematic variation in respondent's WTP.

The final category of bias is instrument related bias. This type of bias can be caused by either the payment vehicle (taxes, donation to NGO, etc.), or the format of the WTP/WTA question (open ended, payment card, dichotomous choice). Rowe et. al. (1980) found that stated WTP was higher for surveys that presented hypothetical income tax increases, than for surveys that presented hypothetical entrance fees.

Mitchell and Carson (1989) identity three categories of validity; content, criterion, and construct. Content validity relates to whether or not the estimated WTP/WTA from the survey accurately and fully corresponds to the object under investigation. "Analyst must decide for themselves whether a particular CVM questionnaire has asked the right questions in the appropriate manner" (Mitchell & Carson 1989). Willis and Garrod (1990) conclude that a general improvement in survey questionnaire design has meant that content validity has not been regarded as too great a problem in recent years. "Criterion validity is concerned with whether the measure of the construct (the CVM survey) is related to other measures which maybe regarded as criteria" (Mitchell & Carson 1989). Using simulated markets for the criterion, Heberlein and Bishop (1986) conclude that the WTP estimates from their CVM were valid estimates of the 'real' WTP, as revealed by the market simulation. Finally, construct validity involves the investigation of whether estimates produced by a CVM study relate to explanatory variables as predicted by economic theory. For example a respondents WTP should increase with income, and decrease with distance from the environmental amenity in question.

2.1.4 NOAA Blue Ribbon Panel

CVM was thrust into the spot light with the 1989 Exxon Valdez oil spill. Paul Portney (1994) explains that in the ensuing lawsuit against Exxon, the state of Alaska commissioned one of the most extensive CVM studies ever. 1,050 households in all 50 states were surveyed. The study estimated the harm caused to Americans by the loss of existence, and bequest values. To get at these values the designers of the study proposed a hypothetical escort ship program that would ensure no other oil tankers would stray off course and onto the rocks. This program would be funded by a one-time tax on the oil companies and a one-time payment by households. The average willingness to pay (WTP) was $94 the median was $31. The median was aggregated to $2.8 billion for the entire US. The state of Alaska argued that Exxon should be held liable for this amount as damages caused to the American public. This would be in addition to the billions Exxon paid for clean up. As a result of the Valdez spill Congress passed 1990 Oil Pollution Act, to reduce potential for another spill. This act directed the National Oceanic and Atmospheric Administration (NOAA) to write its own regulations governing damage assessment. The NOAA asked nobeloriates Kenneth Arrow & Robert Solow to determine if CVM was capable of providing estimates of lost nonuse values that are reliable enough to be included in damage compensation. These economists brought together a panel that met 8 times from June to November 1992. A final report was published in the Federal Register in January of 1993. The report stated that: "The panel concludes that contingent valuation studies can produce estimates reliable enough to be the staring point of a judicial process of damage assessment, including lost passive use values." It also set guide lines for future applications of CVM with respect to damage assessment.

National Oceanic & Atmospheric Administration Requirements for Valid CVM Studies

1. CVM studies should rely upon personal interviews rather than telephone surveys when possible, and on telephone surveys in preference to mail surveys.
2. CVM surveys should elicit willingness to pay (WTP) to prevent future damage rather than minimum compensation required for an incident that already occurred.
3. CVM surveys should utilize the referendum (dichotomous choice) format; that is, the respondents should be asked how they would vote if faced with a program that would produce some kind of environmental benefit in exchange for higher taxes or product prices.
4. CVM surveys must begin with a scenario that accurately and understandably describes the expected effects of the program under consideration.
5. CVM surveys must contain reminders to respondents that a willingness to pay for the program or policy in question would reduce the amount they have available to spend on other things.
6. CVM surveys must also include reminders of substitutes for the commodity in question. For example, if respondents are being asked how they would vote on a measure to protect a wilderness area, they should be reminded of other wilderness areas that already exist.
7. CVM surveys should include one or more follow-up questions to ensure that respondents understood the choice they were being asked to make and to discover the reasons for their answers.

(Federal Register 1993).

2.2 Hedonic Property Price Method

2.2.1 Definition

The hedonic property price method uses regression analysis with prices of homes as the dependent variable, and the normal factors that one would expect to have influence on a home's price (age, size, number of bedrooms, type of neighborhood, etc.) as the independent variables. In addition, variables representing the existence of, or the proximity to an environmental amenity are included to "teases out" their marginal value to homebuyers. The fact that this method relies on observed market transactions makes it appealing. The other two non-market valuation techniques, contingent valuation and travel cost, rely on survey data, which may have a number of practical and theoretical problems. A limitation of the hedonic method is that its application is limited to environmental amenities located near an active real-estate market. Also, the hedonic method only measures the economic benefits of a resource as they relate to the housing market. These benefits are 'use' values restricted to homeowners. However, a natural resource might provide non-use values (such as species preservation). It may also provide use values to nonresidents who enjoy the resource, while visiting the area.

2.2.2 Hedonic Theory

The hedonic price method has been used in economics for many years. Recently, Freeman (1993) presented an astute treatment of the hedonic theory. What follows is drawn from his chapter on property price models.

Hedonic property price method comes from the theory of rents. Rent theory states that the price at which a piece of property sells is equal to the present value of all future rents that will be produced by that property. If the property is to be used as a consumer's good instead of a producer's input, the environmental differences will also be reflected in market prices, as the present value of future all benefits that a consumer will derive from those amenities. For example, a consumer will derive higher benefits, and therefore pay more for a home located near a beautiful forest than she will from an identical home located next to a municipal land fill. Ridker (1967) was the first to apply this theory by investigating the effect of air quality on residential housing prices in St. Louis.

Following Freeman's notation, the framework for the hedonic price method is as follows. Assume consumers face the problem of maximizing their utility functions;

$$U=U(X, Q_I, S_I, N_I)$$

X= Unitized composite good.
Q_I= Vector of environmental amenities at the *ith* home site.
S_I= Vector of structural characteristics of the *ith* home.
N_I= Vector of neighborhood characteristics at the *ith* home site.

Assuming that the housing market is in equilibrium, and that housing and it's characteristics are weekly separable from the composite good, the price of the *ith* house can be taken to be a function of environmental, structural, and neighborhood characteristics. The hedonic price function is denoted as follows.

$$P_h=P_h\ (S_I, NI, QI)$$

In general, this function is nonlinear, due to the expectation that the marginal implicit prices for many of a home's attributes will not be constant.

When the consumer maximizes her utility subject to an income restraint; $M-P_h-X=0$. The first order condition for the choice of the environmental amenity q_j is:

$$\partial U/\partial q_j \,/\, \partial U/\partial X = \partial P_h/\partial q_j$$

On the RHS above, the derivative of the hedonic price function with respect to environmental amenity *j* gives the marginal implicit price of that amenity. At the utility maximizing point the consumer's marginal willingness to pay (LHS) is exactly equal to this price. However, everywhere else it's likely that the consumer's marginal willingness to pay is different from this implicit price. This implies that any welfare estimate, based on consumer's marginal willingness to pay (demand) function, would require either a simplifying assumption (i.e. constant marginal willingness to pay) or a secondary estimation procedure.

2.2.3 Recent Applications of the Hedonic Method

Since its inception there have been hundreds of applications of the hedonic property price method. Recently, Mahan, Polasky, and Adams (2000) estimated the value of wetland amenities in the Portland, Oregon area. Using 14,233 observations, the sales price of residential homes were regressed upon a set of associated explanatory variables consisting of structural, neighborhood, and environmental characteristics. The environmental characteristics were classified using six wetland categories (lakes, rivers, forested wetlands, etc.) which were expected to influence home purchaser's marginal willingness to pay. Two alternate models were estimated. In Model (1) environmental characteristics were represented with dummy variables for each type of wetland, and variables for distance to, and size of wetland (regardless of type) were included. In model (2), the authors used variables for distance to, and size of each wetland type. For both models a double-log equation was specified for the hedonic price function. Both models had high R-squared measures, and similar coefficient estimates. Of particular interest is the result form model (1), which indicated that the estimated marginal implicit price for reducing the distance to the nearest wetland by 1,000 feet was $436.17.

Mahan, Polasky, and Adams concluded their article with a second-stage analysis of the consumer's willingness to pay function. Following the suggestion of Freeman (1993) the authors used data from segmented markets. Separate regressions were run for each of five segmented markets within Portland, generating hedonic price functions for each market. Then each homebuyer's marginal implicit price for size of nearest wetland was computed and regressed upon the observed quantities of wetland size and socio-economic variables from the market segments. This attempt to estimate a demand curve was judged to be a failure when the regression results indicated increasing marginal willingness to pay for wetland size.

Sian Mooney and Ludwig Eisgruber (2001) also applied the hedonic property price method to water resources in Oregon. Recently a plan was developed to restore coastal salmon populations in western Oregon. Part of the plan included planting treed buffer zones along streams and rivers, with hopes that the increased shade from the trees would cool the average water temperatures, thus providing improved habitat for migrating and spawning salmon. The authors attempted to quantify the effects of these buffer zones on the values of residential properties.

The data for the analysis came for the Mohawk watershed, and consisted of 705 observations of single family residences. Assessed home values, from the county taxation department, were used as the dependent variable in the regression analysis. The assessed value was used because only 105 observations of actual market transactions were available. The independent variables in the regression included common structural and neighborhood characteristics. The environmentally descriptive variables used were a dummy variable for the existence of an adjacent stream and a continuous variable for the width of buffer zone (if any). The authors selected a Box-Cox transformation for their model. This transformation allows "the data to determine the appropriate functional form" (Mooney & Eisgruber 2001). Many alternate models were estimated and tested for specification errors using Ramsey's RESET test (Ramsey 1969). Two models passed the test for specification error, both used the natural-log of home value as the dependent variable, and both resulted in similar coefficient estimates. The models were checked for heteroskedasticity, and were re-estimated using White's method. The structural and neighborhood coefficients were all of the expected sign, and most were significant at the 5 percent level. The coefficient for stream frontage indicated that being adjacent to the Mohawk River increased a home's value by 7 percent. This value was lower than in other similar studies cited. The coefficient for width of buffer zone was negative, and barley significant at the ten percent level. Evaluated at the sample means this coefficient indicated that the market value of a home would fall $85.50 for an additional one foot of buffer from the stream. The authors conclude that their findings could have "important implication for the general design of riparian restoration and incentive programs (Mooney & Eisgruber 2001).

In addition to measuring the effect of proximity to a water resource, the hedonic technique can be extended to measure the effect that water quality has on property value. Leggett, and Bockstael (2000), attempt to calculate the potential benefits from a water quality improvement in Chesapeake Bay using the hedonic property price method.

The study site for Leggett and Bockstael's 2000 article is Anne Arundel County in Maryland, located on the western shore of Chesapeake Bay. The authors note that this area is particularly well suited to a hedonic study on water quality because of the active real estate market is along an irregular coast line, with multiple sources of pollution, which result in varying levels of water quality within the sample. The data set contains almost 1,200 observations of home sales from 1993 to 1997. As is normally the case, the dependent variable in the regression was the actual sale price of homes, which were adjusted using the Consumer Price Index. Due to a lack of data on the physical characteristics of the homes, the county assessor's appraised value of the structure was used in place of the usual vector of structural variables. Other independent variables included size of lot, distance to Baltimore and Annapolis, and percentage of nearby land that is developed, wetland, or open. The authors note that the sources of pollution may also have an effect on property values, and if left out of the regression may bias the measurement of pollution's effect. They control for this 'emitter effect' by including distance to the closest nationally permitted emitter of water pollution on the right hand side of the regression. The pollution variable is the level of fecal coliform bacteria, which is calculated as the weighted average from the three closest monitoring stations from 104 within the study area. Linear, semi-log, and double log specifications for the hedonic price function were estimated. All of the models performed well, with R^2 measures ranging from 0.63 to 0.75. All the various specifications produce significant coefficient estimates for fecal coliform bacteria, with the expected negative sign.

Leggett and Bockstael (2000) conclude by noting that although the hedonic price function cannot be used to calculate a welfare benefit estimate for a large-scale change in water quality, it does provide an upper bound for this benefit. They calculate that a reduction of fecal coliform bacteria to the state standard, would affect 494 properties with and upper bound benefit estimate of $12.125 million.

Another study that related the quality of nearby water resources to property values was performed by Michael, Boyle, and Bouchard (2000). These authors not only investigated how water clarity (as measured by Secchi disk readings) effected lake home values, but they also examined "the effects of the alternative environmental variables on implicit prices" (Michael, Boyle, Bouchard 2000 p. 283).

This study developed nine different measures of water clarity using measures at, and preceding the time of sales. Telephone interviews with recent homebuyers in the area indicated that the level of water clarity in the adjoining lake had effected their purchase decision, but in varying ways. The authors point out that if consumers truly perceive water quality in heterogeneous fashion, then multiple variables for water quality should be included in the hedonic prices function to account for the varying consumer perceptions.

The study ran nine regressions for each of three study areas. Each one of the nine regressions utilized a different measure of water clarity. The regressions did not produce statistically different implicit prices for water quality. However, Michael, Boyle, and Bouchard point out that there are large enough differences in the estimated implicit prices that if used in a cost benefit context, the prices may lead to different policy recommendations. The authors conclude that their mixed findings highlight the need for careful selection of environmental variables when specifying a hedonic price function.

Further application of the hedonic property price method in the context of water resources was performed by Spalatro, and Provencher (2001). These authors investigated the effects of zoning regulations on lake front property values in northern Wisconsin. Recently many counties in this state have increased the minimum allowable frontage for residential lakeside properties from 100 feet to 200 feet. Spalatro and Provencher (2001) identify and attempt to measure two different economic effects that this policy change could cause. First, is an expected negative 'development effect' which results from the restriction of the flow of private goods, and services from the land. Second, is an expected positive 'amenity effect' which results from the lower development densities for lakes with the higher minimum frontage rule.

The data consisted of sale information from 893 undeveloped plots of land from 1986 to 1995. Developed parcels were excluded due to unavailability of structural characteristics of improvements. A semi-log specification was used for the hedonic price function. The dependent variable was the natural log of price per frontage foot. The independent variables included variables describing the land parcel, the associated lake, nearby towns and national forests, and the zoning policy at that location. The price function was estimated for each year separately. The authors note that previous studies have found that hedonic regressions are not stable over time, and that their results reject a model in which parameters are fixed over a ten year period.

The results of the regression conform to the expectations. However, the coefficient that reveals the development effect passes a test of significance in only one year. "The coefficients on the amenity effect are generally positive and significant at the 90% confidence level" (Spalatro and Provencher 2001 p. 475). By investigating the expected sale price of the entire sample under the two alternate minimum frontage requirements, the authors calculate that the amenity effect dominates the development effect. They also conclude that increasing the minimum frontage requirement at relatively undeveloped lakes in the study area would have a positive economic effect.

Yet another application of the hedonic property price method was performed by Acharya and Bennett (2001). This article analyzed the property value effects of various nearby environmental amenities, including lakes and the Atlantic Ocean, and the effects of surrounding land use patterns. Using a rich GIS data set the authors investigate whether variables that reflect multiple environmental aspects of the surrounding landscape do a better job of describing preferences for housing choices, than do more traditional explanatory variable such as whether an area is urban, or rural. The study was conducted in New Haven County Connecticut, and consisted of 4,000 observations over a three year time span.

Acharya and Bennett (2001) define three classes of variables to describe environmental variation around a home site. First is the traditional variety, which they call aggregate variables. For this study only two aggregate variables are defined Urban and Rural, both of which are binary dummies. Second, the authors define a set of 'mosaic variables', which describe the "relative number of types, sizes, or shapes of land use patches" (Acharya and Bennett 2001 p. 225) of the area surrounding a home site. The mosaic variables are percentage of open space, diversity of surrounding land use, richness of land use variety relative to the entire study area, and the human population density. The third class of environmental variables is defined as 'spatial pattern'. These variables describe the location of the home site in relation to highways, lakes, and the Atlantic Ocean.

A semi-log specification was used for the hedonic price function, where the natural log of the sale price was used as the dependent variable. Acharya and Bennett estimated three different models. All three used the same set of structural, and neighborhood variables. The first used only the aggregate variables to describe the surrounding environmental conditions. The other two used the mosaic and spatial pattern variables, one using a ¼ mile radius around the home, the other using a one-mile radius.

In all three models most of the structural, and neighborhood variables were found to be of the expected sign, and significant. The two models that use the mosaic and spatial variables indicate that a home's relative location and the types of surrounding land uses have significant effects on the sale price of homes. Of particular interest to this thesis are the estimated coefficients for distance to nearest lake and distance to the ocean. The coefficients were of the expected sign and significant at the 5% level.

A final hedonic study referenced for this thesis was preformed by Spahr and Sunderman (1999), on the value of vacant land in the Jackson Hole area of Wyoming. While the main motivation of this article was to analysis the difference between hedonic models for agricultural and residential properties in Jackson Hole, the study included two aspects that are of interest to this thesis. First, the hedonic models specified variables for the existence of streams on the property, and for frontage along the Snake River. Second, the authors utilize an interesting method for including time of sale in the hedonic model.

Residential property sales in this area are relatively thin, and consequently to attain a data set of adequate size observations from a nine-year period were included. To account for time of sale the authors defined the date of sale as a linear combination of the end points of the year in which the sale occurred, this method was first proposed by Bryan and Colwell (1982). For example, a sale in September of 1990, results in a value of 0.25 for the 1990 variable and a value of .75 for the 1991 variable. Spahr and Sunderman note that this allows for a price continuum with respect to time, rather than a step function.

The other portion of this article that is of interest to this thesis is the inclusion of the effects of small streams, and the Snake River in the hedonic price function for residential property. The authors use a set of dummy variables to account for stream and river effects. The dummy variables for both streams and the Snake River were positive, as was the expectation. However, the coefficients indicate a much higher implicit price for streams, and only the stream coefficient passed a test of significance. In fact, the Snake River dummy variable's t-stat was only 0.6. In a footnote the authors explain that counter to what might be expected, the Snake River is not necessarily a positive amenity. They note that it is best described as a large debris field with a small thread of river running down the center. As a result land owners with frontage along the Snake, may have a considerable amount of unusable land.

2.3 Benefit Transfer

2.3.1 Benefit Transfer Definition

In 1992, Water Resource Research published a special volume dedicated to the analysis of benefit transfer. This was the first formal study of a practice that has been in use since the early 80's when environmental regulations were first held up to rigorous cost benefit analysis (Desvousges 1992). Some definitions relating to benefit transfer put forth in the 1992 Water Resources Research were:

> "Benefit Transfer is the transfer of existing estimates of non-market values to a new study which is different from the study for which the values were originally estimated" (Boyle & Bergstrom 1992)
>
> The location where an existing study was conducted is termed the "study site" and the location under consideration is termed the "policy site". The calculated cost and/or benefits are then "transferred" from the study site to the policy site (Desvousges 1992).
>
> Benefit transfers "use existing empirical models to estimate how much people's well-being would be improved by some policy action."(Smith 1992)

Research has continued over the past decade with three formal techniques for benefit transfer emerging. The first is simple *benefit value transfer* (BVT). Here a dollar estimate of consumer surplus or mean willingness to pay per unit of an environmental attribute is taken from existing literature and directly transferred to the policy site without any modification. (Smith et. al. 2000) The second method is *benefit function transfer* (BFT) where estimated valuation functions (benefit or demand) for environmental amenities are transferred. This method has the advantage of capturing differences between the study and policy sites, which are explained by the variables in the transferred function. This produces an estimate that is more tailored to the study site. (Sturtevant et. al. 1998) The third benefit transfer technique involves the use of meta-analysis. This last technique collects value estimates from multiple non-market valuation studies, and uses them as observations in a regression analysis that estimates a benefit or demand function. The incorporation of a wide range of studies is seen as the major advantage of the Meta approach. (Sturtevant et. al. 1998)

Two other approaches to benefit transfer exist, and are worth noting. Throughout the 80s unit values adjusted by *expert opinion* were commonly used for benefit transfer. However, economists seem to have shunned this approach, viewing it an unscientific. Bateman (2000) states that there maybe some cases where expert opinion is acceptable, but that more objective adjustment techniques are preferable. No formal analysis of the use of expert opinion has been performed. Recently the EPA and Resources for the Future (1999) have jointly developed a technique termed *Preference Calibration*. This approach assumes a functional form for a utility function that conforms to general economic theory (e.g. bounded by income, decreasing marginal utility). This function is then calibrated using estimates of non-market environmental attributes from existing literature finally, the calibrated utility function is applied the policy site in question (Smith et al 00).

2.3.2. Justification for Benefit Transfer Research

Recognizing the burgeoning use of benefit transfer, the EPA published an entire volume on the topic: *Benefit Transfer; Procedures, Problems, and Research Needs*. Here Bingham (92) makes a case for benefit transfer.

> "It can reduce both calendar time and resources needed to develop original estimates of values for environmental commodities. These estimates are used to evaluate the attractiveness of potential governmental policies, to assess the value of policies implemented in the past, and to identify the compensation required under CERCLA when toxic substances are released into the environment."

However, when first introduced as a formal economic method the use of benefit transfers was commonly met with opposition. Brookshire and Neil (1992) report some economist arguing that benefit transfer is "too complex, potentially intractable, and should be discontinued" (Brookshire and Neil 1992, p. 653).

Benefit transfer will most likely see continued use in policy analysis. Boyle and Bergstrom (1992) defend benefit transfer stating that the argument against its defensible application is to "deny the role of any organized research agenda for expanding knowledge." Further defense of benefit transfer comes from Bergland, Magnussen, and Navrud (1998). They concede that such transfers are less than ideal, but that most attempts at non-market valuations are too, and all could be improved upon if more time and money were available. The universal constraints of time and money seem to be the focal arguments for the development of benefit transfer. Most literature on the subject cites these two reasons. Deck and Chestnut (1992) explain that the benefit of avoided costs from a full original study must be weighed against the increased uncertainly associated with a transfer. Brookshire and Neill (1992) point out that benefit transfers have the same accuracy problems as all non-market valuation techniques, but are of a larger magnitude. So we are left with a balancing act that must be carefully considered by the decision-maker. "In many situations a benefit transfer may provide adequate information for the decision at hand, and therefore be the preferred level of analysis even though an original study might provide more precise benefit estimates."(Deck & Chestnut 1992) An example of this is when a transfer provides a range of benefits that all lie above or below projected costs. In this case the worth of the policy is clear and no further study is necessary (Deck and Chestnut 92). However, there are still many situations where a full-blown non-market valuation will be desirable. There could be a case when no adequate studies are available from which to make the benefit transfer, or that the transfer technique produces ambiguous results. (Deck and Chestnut 1992)

2.3.3 Demand for Benefit Transfer

As desirable as original studies maybe, the real world has demonstrated a healthy demand for the use and development of benefit transfer. McConnell (1992) identified four sources that will ensure the continued use of benefit transfer. First is Executive Order 12291 issued by Ronald Regan, which required that a cost benefit analysis be preformed for all new environmental regulations. The second source of demand identified was from litigation under CERCLA and other similar environmental laws that call for monetary penalties based on assessed environmental damage. Third, McConnell (1992) cited increasing demand from state and local governments for valuation of non-market goods. He identified the anti-urban sprawl movement as one possible source that would be interested in non-market valuation but lacked the resources for an original study. The last potential source of demand for benefit transfer sited was from developing countries. "International agencies are increasingly cognizant of the non-market effects of development projects" (McConnell 1992, p. 234).

2.3.4 Policy Applications of Benefit Transfer

For examples of actual applications of benefit transfer we need look no further than our federal government. "The U.S.D.A. Forest Service (1989) has used benefit transfer for the development of economic values for individual national forests to use in their long range planning processes."(Bhat, Bergstrom, and Bowker 1997) The EPA (2001) presents a protocol for using benefit transfer in their *Handbook for Non-Cancer Health Effects Valuation.* This book was designed for use by EPA employees doing cost benefit analysis to comply with Executive Order 12866 which requires a regulatory impact assessment (RIA) for "economically significant regulatory action". (Federal Register 1998) In a 1999 document, the EPA's Office of Air Quality Planning and Standards outlines the use of benefit transfer to monetize the benefits of air quality regulations. The document covers value and function transfers and refers researchers to Water Resources Research for discussion of the advantages and criticisms of using benefit transfer. (EPA OAQPS 1999) In a 1999 regulatory impact assessment (RIA) for the final Section 126 rule[2] the EPA's Office of Atmospheric Programs (OAP) uses benefit transfer in it's benefit cost analysis. The authors site time constraints as preventing them from conducting an original benefit study. The OAP uses estimated benefits from reductions in nitrogen oxide levels as benefit transfer values for ozone reductions (EPA OAP 1999). The EPA's Office of Solid Waste (1995) prepared a RIA for a proposed increase in emission standards for hazardous waste incinerators. Once again, financial and time constraints prohibited original research. To develop an estimate of property value effects near hazardous waste combustors, the authors used an adjusted unit value transfer. The study site was a municipal waste incinerator in Massachusetts. The average per household per mile willingness to pay estimate from this study was adjusted using median household values in the policy sites relative to the study site. The authors cite a litany of shortcomings in their use of benefit transfer, with the primary

[2] This rule addresses regional transportation issues related to ozone attainment. Certain states are required to take action to reduce emissions of nitrogen oxides (NOx) that contribute to non-attainment of ozone standards in downwind states.

concern being the dissimilarity between the study site and the policy site.[3] However the results indicated a strong positive benefit from emission reductions, although the magnitudes of the benefits were ambiguous.

2.3.5 Types of Benefit Transfers

2.3.5.1 Benefit Value Transfers (BVT)

The practice of transferring unadjusted consumer surplus estimates from study sites to policy sites, known as benefit value transfer, was discredited early on. One of the first studies to test the validity of BVT was Boyle and Bergstrom (1992). The authors attempted to transfer benefits from white water rafting to the Kennebec River in Maine. The process began with thorough literature research. Preference was given to recent studies that employed state of the art data collection techniques and value estimation procedures. Specifically, Boyle and Bergstrom searched for study sites where values had been estimated for white water rafting under various flow regimes. The search resulted in five potential studies. These were evaluated for transferability based on 3 criteria:

1) "The non-market commodity valued at the policy site should be identical to the non-market commodity at the study site"(Boyle & Bergstrom 92);
2) The populations affected by the non-market commodities at the two sites should be identical;
3) The study and policy sites must have the same welfare measure (Either WTA or WTP).

Based only on the first criteria, Boyle and Bergstrom rejected all the potential study sites. They state that "We believe that this is likely to be the case for many specific

[3] The study used for the benefit transfer (Kiel & McClain 95) was based on the total removal of the hazardous waste incinerator located in Andover Massachusetts. While the policy being considered was only a reduction in emissions at 10 similar facilities around the nation.

investigations;" "the values estimated at study sites may not be applicable to the issue at the policy site." (Boyle & Bergstrom 1992)

More recently Bergland, Magnussen, and Navrud (1998) tested benefit value transfer as part of a larger benefit transfer analysis. They explain BVT as the "assumption that the well-being experienced by the average person at the study site is the same as that which will be experienced by the average person at the policy site" (Bergland et. al. 1998). The authors cite two problems with this assumption. First, the socioeconomic characteristics of the average person will likely differ between the sites. Second, the characteristics of the recreation opportunities at the two sites are also likely to differ. Using data from two Norwegian water courses, Bergland et. al. (1998) report their findings as follows; "For both sites we see that the mean willingness-to-pay estimated at (the study) site is at least two standard errors away from the estimated willingness-to-pay at (the policy) site" (Bergland et. al. 1998). Using estimated bootstrap standard errors and t-tests BVT was formally rejected using a 5% significance level.

2.3.5.2 Benefit Function Transfers (BFT)

Even though value transfers can still be found in use by many government agencies, most academic research is now focused on the transfer of entire demand or benefit functions. Loomis (1992) commented that the use of BFT was more conceptually sound. He also noted that the use of the study site's estimated demand function coefficients and the policy site's independent variables should give a reasonable estimate of both the use and the benefits resulting from a change at the policy site (Loomis 1992).

Having estimates for both use and per person benefit is crucial for the aggregation of benefits.

However, Loomis was using the travel cost method which provided him an estimated demand equation. This thesis will be using CVM data to estimate a benefit function. Downing and Ozuna (1996) also used CVM data to investigate the validity of benefit transfer. Their data consisted of survey responses from anglers in the Texas Gulf Coast region collected over three distinct time periods. When discussing BFT, Downing and Ozuna maintain that to test the transferability of benefit functions researchers must investigate confidence intervals for estimated welfare measures, and not the benefit function's coefficients. They explain "nonlinearity could lead to the case where statistically similar benefit functions yield statically different welfare measures" (Downing & Ozuna 1996). The results from this study were disappointing for proponents of BFT. The authors conclude that BFT is "unreliable", and that it cannot be recommended for use in calculating compensation for individuals harmed by a particular policy. Downing and Ozuna blame the nonlinearity of the Logit model that they used, without giving a detailed explanation.

Another study of BFT (and a major basis for this thesis) is Kirchhoff, Colby, and LaFrance (1997). In this article, BVT and BFT are tested for two pairs of water based recreation resources. An original CVM study was performed at each site so that the various transfers could be evaluated. Kirchhoff et. al. (1997) specified a heteroskedastic Tobit model for their data, which resulted in a superior fit compared to a Tobit model under the normality assumption. For evaluation of BFT, the authors also rejected comparison of benefit function coefficients in favor of investigation of confidence intervals. This resulted in a two step procedure for testing the validity of BFT. First the researchers checked if the benefit measure calculated using the study site equation fell within the 95% confidence interval derived from the original study performed at the policy site. Next, for further validation, they investigated if BFT worked in the opposite direction. They checked if the estimated benefit measure at the policy site lay within the 95% confidence interval from the transferred study site equation.[4] The specification of a heteroskedastic Tobit makes the calculation of the aforementioned confidence intervals a non-trivial task. Kirchhoff et. al used "the delta method and a first-order Taylor series expansion" for calculation of the 95% confidence interval. The results of this study were mixed. Out of 30 hypotheses presented, the validity of BFT was rejected 20 times. However, the results substantiated the theory that BFT performs better when the policy and study sites are close substitutes. Kirchhoff et al conclude from their results that: 1. Small differences between study and policy site make are of little matter, but differences in recreation focus can cause benefit estimates to diverge. 2. A single large indicator of recreation site quality is insufficient, and that more subtle measurements of resource characteristics are needed for accurate transfer. 3. The availability and price of substitutes resources, if not accounted for in the benefit function can cause biases in BFT.

[4] The notation used in the article is helpful in understanding . CV is compensating variation (benefit estimate), CI is confidence interval and subscripts S & P stand for study and policy site respectively. The null hypothesis is H_o: $CV_{p|s}=CV_{p|p}$ and the two tests are $CV_{p|s} \in CI_{p|p}$ and $CV_{p|p} \in CI_{p|s}$.

2.4 Literature Review Conclusion

The purpose of this chapter has been to establish the terminology that will be used in the chapters to follow, familiarize the reader with the topics that will be investigated, and to present similar studies that have been conducted. The review of the contingent valuation method described the elements of the survey instrument, discussed many validity issues associated with CVM, and presented the NOAA guidelines. This information is important to understand and asses the quality of the Kern River CMV in chapter 3. Section 2.2 reviewed Freeman's (1993) chapter on hedonic property price method, is critical reading for anyone interested in, or working with the hedonic method. The reader should have gained a clear insight regarding the values being measured with this method. The review of the two applications of the hedonic property price method give a context for comparison with the Tanque Verde study presented in chapter 4. Finally, the section covering benefit transfer showed that what may appear to be an ad hoc method of valuation is actually a technique that is in high demand and rigorously studied by economists. The reader should now be familiarized with the lexicon, methods, and uses of benefit transfer, and should understand the importance of testing the method, as is done in chapter 5.

Chapter 3

3. Kern River Preserve CVM Study

The topic of this chapter is a contingent valuation study of the Kern River Preserve (KRP) in south-central California. This is the first two original non-market valuations presented in this thesis, and the results will be used to test the performance of benefit transfer in Chapter 5.

3.1 Study Site and Survey Instrument[5]

The Kern River Preserve is owned and operated by Audubon California, a non-profit organization that works to conserve and restore California's natural ecosystem. The preserve is over 1000 acres of lowland riparian forest, and has been recognized as a "Globally Important Bird Area". It is located 57 miles northeast of Bakersfield, and had an estimated 6,500 visitors in 1999. The primary recreation activity at the KRP is bird watching, but other activities include boating, fishing, and observation of other wildlife.

The contingent valuation survey used for this study had a dual purpose. Not only was it designed to elicit a maximum willingness to pay information from respondents, it also collected trip expenditure information to be used for a local economic impact assessment. The inclusion of this additional section on trip expenditures generally goes against guidelines for optimal CVM survey design, which cite survey brevity as important to maximizing response rate (Mitchell & Carson 1989). However, the response

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[5] This section is based on the data collection report written by Liz Smith (2001) and the Kern River Preserve's web site (www.audubon.org/local/sanctuary/kernriver). At the time Ms. Smith was a graduate research assistant here at the University of Arizona.

rate for this study was over 90%, indicating that the survey was not perceived as intolerably long. The hypothetical situation presented in the survey is that the water flows for the Kern River are threatened. A non-profit organization is raising money to acquire water rights and promote regional water conservation in order to maintain the water flows, and consequently the KRP's ecosystem. It goes on to stipulate that if not enough money is raised; in stream flows will be diminished, causing trees to die, and the loss of the habitat for birds and other wildlife. Maximum WTP is elicited with a payment card that presents dollar amounts ranging from zero, to $1000. The survey asks respondents to check a box next to the amount they would be willing to pay annually to preserve the Kern River's flow level. The WTP elicitation is followed by a few questions asking the respondent why they answered the way they did. These questions are important in identifying protest bids. The final section collects the socioeconomic information necessary to estimate a WTP function. The surveys were administered on select weekends during the peak tourist season of March through August of 2000, resulting in 254 completed survey forms. The surveys were administered by a University of Arizona graduate student, and trained volunteers. A copy of the survey instrument used is presented in appendix A.

Because the survey instrument uses a combination of a hypothetical environmental gain, and a WTP question, compensating surplus (CS) is the Hicksian surplus being measured. The hypothetical environmental change is considered a gain because the baseline environmental condition, without any action, would be the degradation of the KRP. As noted in section 2.1.1.3., CS is the amount of money that must be taken away from a consumer to return him to his baseline level of utility.

3.2 Regression Variables

The original number of surveys was 254, but 8 observations were removed after being determined to be protest bids.

Variables Selected for Inclusion in Final WTP Function

WTP: (Willingness to Pay) The indicated WTP on the payment card was transformed from an ordinal 1-12 representative variable to monetary value equal to mid point of their maximum WTP and the next higher choice.[6] WTP is the dependent variable in the regression analysis.

PRVTRPS: (Number of Previous Trips) This variable was created using a combination of two survey questions. The first asked if it was the visitor's first trip the second asked if not, how many times had the respondent previously visited.

EDU: (Education) This variable has been transformed from qualitative data to a level of education measured in years.[7]

INC: (Income) Respondents were given income ranges from which to select. The midpoint from the range selected is used for this variable.

AGE: Respondent's age in years

ECO: This is a binary dummy variable that equals 1 if the respondent indicated that he/she was a member of an organization that supports conservation, environmental or wildlife concerns.

GENDER: Binary dummy variable 1=female, 0=male.

BIRD: This is a binary dummy variable that equals one if the respondent indicated that birding was his/her primary activity while at the KRP.

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[6] This reflects the theory that the true maximum WTP in a payment card survey lies somewhere between the amount indicated and the next highest bid.

[7] The data was transformed in the following way; 1 (High school) =12 years, 2 (Some College) =14 years, 3 (Completed College) =16 years, 4 (Some Graduate School) =18 years, 5 (Completed Graduate School) =20 years.

3.3 Missing Data

Of the 246 observations, many were incomplete. That is, one or more of the variables fields was left blank. Possible strategies for dealing with missing data are:

1. Drop entire observation (list wise deletion).
2. Replace with sample mean.
3. Use OLS regression to estimate missing data (Conditional Mean Imputation)

To form a baseline from which a comparison can be drawn, the sample means and variances were calculated for each of the selected variables based on all available data points. Table 3.1 presents these results, in addition, the number of missing data points for each variable.

Table 3.1 KRP Data Summary

	Obs	Mean	Std. Dev.	Min	Max	Missing
WTP	228	72.093	131.499	0	1250	18
PRVTRPS	246	2.193	4.291	0	50	0
MAINREAS	236	0.542	0.499	0	1	10
BIRD	213	0.634	0.483	0	1	33
GENDER	238	0.563	0.497	0	1	8
RES	246	0.146	0.354	0	1	0
AGE	238	49.479	13.814	21	84	8
EDU	240	17.85	2.198	12	20	6
INC	217	73191.2	64586.2	9000	625000	29
CHLDRN	235	0.191	0.394	0	1	11
ECO	234	0.829	0.377	0	1	12
ODD	230	67.17	76.891	0	365	16

The first approach for dealing with missing data is to simply drop any observation that has missing information (list wise deletion). The advantages of this strategy are simplicity and the fact that list wise deletion will yield valid inferences if the data is "missing completely at random" (MCR) (Little 1992). However, this usually results in the loss of significant amounts of data. Also, income and other variables in our data set are generally suspected of not being MCR[8]. The results of list wise deletion are shown in the Table 3.2.

Table 3.2 Results of List Wise Deletion

	Obs	Mean	Std. Dev.	Min	Max
WTP	157	76.561	145.367	0	1250
PRVTRPS	157	1.904	3.121	0	27
MAINREAS	157	0.567	0.497	0	1
BIRD	157	0.624	0.486	0	1
GENDER	157	0.631	0.484	0	1
RES	157	0.121	0.327	0	1
AGE	157	47.904	13.610	21	80
EDU	157	17.962	2.178	12	20
INC	157	75423.570	55791.310	9000	375000
CHLDRN	157	0.191	0.394	0	1
ECO	157	0.809	0.394	0	1
ODD	157	65.732	69.498	0	365

List wise deletion is results in the loss of 89 observations (36% of the data set). However, the change in the summary statistics appears to be minimal. In fact, for all the variables we fail to reject the null hypothesis that the mean after list wise deletion is equal to the original mean. The t-statistic[9] for this hypothesis, and the percentage changes in mean and standard deviations are given in Table 3.3.

[8] It has been posited that respondents with unusually high or low incomes will be more likely to withhold income information.

[9] For rejection of the null hypothesis the t-stat must be above± 1.96, for a 95% confidence level.

Table 3.3 Changes from List Wise Deletion

	% Change in Mean	% Change in Std. Dev.	t-stat
WTP	6.20%	10.55%	-0.0340
PRVTRPS	-13.18%	-27.27%	0.0674
MAINREAS	4.61%	-0.40%	-0.0501
BIRD	-1.58%	0.62%	0.0207
GENDER	12.08%	-2.62%	-0.1368
RES	-17.12%	-7.63%	0.0706
AGE	-3.18%	-1.48%	0.1140
EDU	0.63%	-0.91%	-0.0510
INC	-0.0346	-13.62%	3.0501
CHLDRN	0.00%	0.00%	0.0000
ECO	-2.41%	4.51%	0.0531
ODD	-2.14%	-9.61%	0.0187

These results indicate that using list wise deletion should result in reasonably accurate parameter estimation. After researching the alternatives, I've decided to use the list wise deletion method, with the hope that the missing data is at least close to being missing completely at random. I've judged this to be a better alternative than using the conditional mean imputation method which is likely to cause under-stated standard errors (Little 1992).

3.4 Regression Results

Following the method used in many CVM studies, the data will be analyzed using a Tobit model. McDonald and Moffitt (1980) explain that in a Tobit model it is assumed that the dependent variable has a limiting value at which observations are censored. This is the situation with KRP data, where there are 25 observations with a stated WTP of zero. The Tobit technique uses all observations, both those at zero and those with positive WTP, to estimate a regression line. In general the Tobit model is preferred over techniques that estimate a line only with the positive WTP observations (McDonald & Moffitt 1980). Following the notation of Maddala (1983) the likelihood function for the standard Tobit is:

$$L = \prod_{0}\left[1-\Phi\left(\frac{X_i\beta}{\sigma_i}\right)\right]\cdot\prod_{1}\frac{1}{(2\Pi\sigma_i^2)^{1/2}}\cdot e^{-(1/2\sigma_i^2)(WTP_i-\beta' x_i)^2}$$

$$\sigma_i = \sigma\cdot e^{(\gamma\cdot g_i)}$$

Where the first product is over the 25 observations for which WTP=0 and the second product is over the rest of the observations for which WTP>0.

Arabmazar and Schmidt (1982) point out a significant short coming of the Tobit model. Unlike the standard linear regression model, which is consistent but not efficient in the presence of heteroskedasticity, the authors show that the Tobit model is inconsistent when the disturbances are non-spherical. As a solution, Maddala (1983) suggests that the researcher make some reasonable assumption about the structure of the error terms, and include them explicitly in the regression analysis.

Multiple alternative specifications for the functional form of the Tobit model were investigated, for the KRP data. In addition to linear forms, quadratic and logarithmic transformations of the variables were also specified in various combinations. A final version of WTP for KRP preservation was selected based upon the best overall fit, the best fit for variables of theoretical importance[10], and the level of multicollinearity detected among the independent variables. The variables used, and the regression results are presented in Table 3.4.

Table 3.4 KRP Regression Results

	Coefficient	Standard Error	T-Stat
Regression Function			
PRVTRPS**	8.83619	4.061168	2.176
EDU**	8.616829	4.093911	2.105
LNINC[11]*	26.91131	14.02958	1.918
AGESQ[12]	-0.01008	0.00751	-1.343
Constant**	-395.161	152.1698	-2.597
Heteroskedasticity Function			
ECO**	0.97865	0.144741	6.761
GENDER**	-0.77918	0.109905	-7.09
BIRD**	-0.90674	0.108432	-8.362
σ**	150.9806	25.3025	5.967
Log-likelihood	-836.6374		
Mean WTP	76.56		
E[WTP]	73.32		

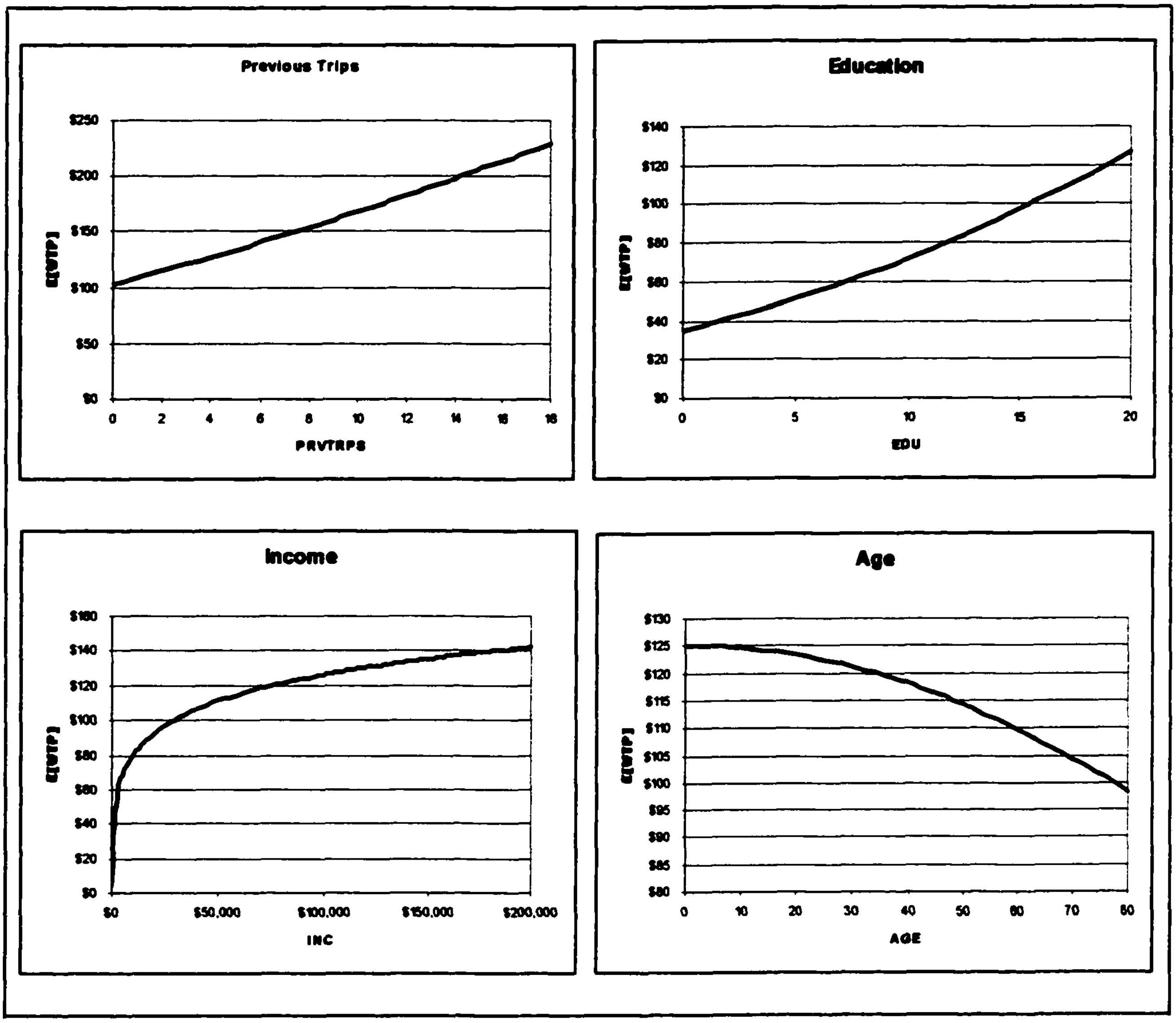
* Significant at the 5% level
** Significant at the 10% level.

The regression coefficients are all of the expected sign, and all but one pass a significance test at the 10% level. Number of previous trips to the KRP, level of education, and income[13] all have positive effects on expected WTP. The variable age has the expected negative effect. Charts 3.5 that illustrate the effects of each variable on an average

[10] A variable of theoretical importance is one that general economic theory predicts will have significant impact on WTP. For example it is generally accepted that 'Income' will have a positive effect on WTP.
[11] LNINC is the variable for income after a logarithmic transformation.
[12] AGESQ is the AGE variable squared, to accommodate a nonlinear relationship with WTP.
[13] Note that income's and Age's effects on expected willingness to pay are nonlinear.

observation[14] are often useful for understanding the independent/dependent variable relationship.

Graph 3.5 Marginal Effects of Variables



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[14] The sample means are PRVTRPS=1.9, EDU=17.96, LNINC=10.98, AGESQ=2478.89, and average standard error=174.13

It is important to note that the regression coefficients are not equal to the marginal effects of the independent variables on expected WTP. Following the procedure in Norris and Batie (1987), the "adjusted coefficients" which represent the effect of a one unit change on WTP are calculated as follows:

$$\frac{\partial E[WTP]}{\partial X} = \Phi\left(\frac{X'\beta}{\sigma}\right)\left(\frac{\partial E(WTP^*)}{\partial X}\right) + E(WTP^*)\left(\frac{\partial\Phi\left(\frac{X'\beta}{\sigma}\right)}{\partial X}\right) = \Phi\left(\frac{X'\beta}{\sigma}\right)\beta$$ [15]

Where WTP* represents only positive values of WTP. Table 3.5 presents the results of this marginal effects equation, and the associated standard errors. Also for comparison purposes the results of a heteroskedasitc OLS model are presented in Table 3.6.

Table 3.6 Adjusted Coefficients

Independent Variable	Adjusted Coefficients	Standard Errors[16]	OLS Coefficients	OLS Std. Errors
PRVTRPS	5.807	2.786	7.448	3.361
EDU	5.663	2.851	7.138	2.826
LNINC[17]	17.687	9.692	20.155	9.313
AGESQ[18]	-0.0066	0.0051	-0.0067	0.0057

The adjusted coefficients from the heteroskedastic Tobit and the OLS coefficients are of the same sign and of similar magnitudes. This implies that regardless of the functional specification the marginal effects of the explanatory variables are roughly the same.

[15] Note that this equation hold only if the X variable does not appear in the heteroskedastic term. If the variable X_i does appear in the heteroskedastic term the proper equation is:

$$\frac{\partial E[WTP]}{\partial X_i} = \beta_i\left[\Phi\left(\frac{X'\beta}{\sigma}\right) + \phi\left(\frac{X'\beta}{\sigma}\right)\left(\frac{1-X'\beta}{\sigma e^{X'\beta}} + \sigma e^{X'\beta} - \frac{1-X'\beta}{2}\right)\right]$$

[16] Standard errors for adjusted coefficients were calculated using the delta method.

[17] Note if the marginal effect of LNINC=21.32267 then the marginal effect of INC = 21.32267/INC.

[18] Note if the marginal effect of AGESQ=-0.00425 then the marginal effect of AGE = -0.00425*2*AGE.

For the heteroskedastic function the following specification was used:

$$\sigma_i^2 = \sigma^2 e^{(\gamma_1 ECO + \gamma_2 GENDER + \gamma_3 BIRD)^2}$$

This specification, and the gamma estimates from the regression, imply that membership in an environmental organization (ECO) increases the models variance, while being female or being a birder decreases the models variance.

Unlike OLS regression, there is no generally accepted goodness of fit statistic that can be applied to the Tobit model. However, Veall and Zimmermann (1994) reviewed many possible pseudo R^2 measures, three of which are presented below.

Dhrymes 1996	.0237
McKelvey and Zavoina 1975	.02001
Aldrich and Nelson 1984	.359

These measures indicated that the model explains little of the total variation in WTP, but exactly how little is unclear.

There are two commonly suggested specifications tests for Tobit models. First is a likelihood ratio test on a homoskedastic model, verses a model where all the coefficients are constrained to be zero (LR_0). The other is also a likelihood ratio test of the heteroskedastic model verses the homoskedastic model (LR_{HET}). The results of these tests are presented in Table 3.7.

Table 3.7Likelihood Ratio Tests	
Likelihood ratio test for homoskedastic model vs. all coefficients equal to zero.	$LR_0 = 17.39 \sim \chi_4^2$ $P(\chi_4^2 > 17.39) < 0.5\%$
Likelihood ratio test for heteroskedastic vs. homoskedastic models.	$LR_{HET} = 70.57 \sim \chi_3^2$ $P(\chi_3^2 > 70.57) < 0.5\%$

We reject both null hypotheses that the restricted model is correct, implying that the model is explaining variation in WTP at a statistically significant level, and that the heteroskedastic version is an improvement over the homoskedastic model.

3.5 WTP Distribution

Because they illustrate that bid values respond to socioeconomic variables in appropriate fashion, the estimation of the WTP function is a critical step in a CVM study. However, the results of the regression have little in the way of policy implications. It is the WTP bids themselves that are the most important to policy makers and researchers. Other than reporting the mean, median, or expected value, what else can be said about the WTP bids? One possibility is that the distribution of bid values may be of interest. This may be the case when the hypothetical environmental change proposed in a CVM survey is actually being considered for implementation. If the successful provision of the environmental improvement depends on contributions, or payments by visitors to a site, then an accurate estimate of the probability distribution of willingness to pay would be helpful in estimating the amount of money that would be raised at various contribution levels. However, the common practice of presenting WTP amounts in a histogram, only presents the values collected and doesn't provide an estimation of the true distribution. This distribution is expected to be smooth and continuous, not step like and discontinuous like a histogram. To provide an estimate of the true distribution of WTP values, the data from the KRP was used for a kernel density estimate. A kernel density estimate assigns probability distributions to each WTP observation, and then sums the probabilities at each point in the range of possible WTP values. However, the common version of this method causes probability to be assigned to negative WTP values. Since the expectation is that WTP values are truncated at zero, the individual kernels need adjustment to account for this expectation. This was done by dividing the PDF for each kernel by its CDF evaluated at zero. This adjustment ensures that when the kernel density estimate is evaluated only for positive values, its integral still equals one. The equation for the kernel density estimate used is:

$$KDE(WTP_O) = \frac{1}{n \times h} \sum_{i=1}^{n} \frac{\phi\left(\dfrac{WTP_O - WTP_i}{h}\right)}{\Phi\left(\dfrac{WTP_i}{h}\right)}$$

$n = 232$ = Number of non - protest WTP bids.

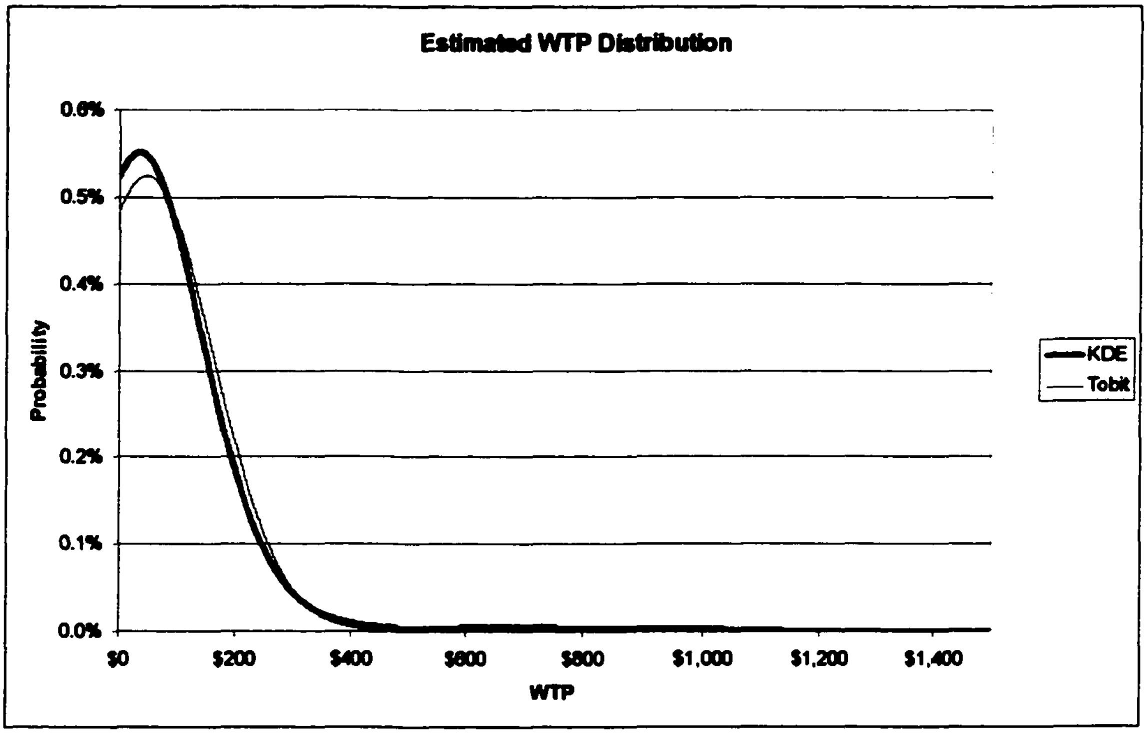
$h = 100$ = Smoothing parameter.

ϕ = Standard normal probability density function.

Φ = Standard normal cumulative density function.

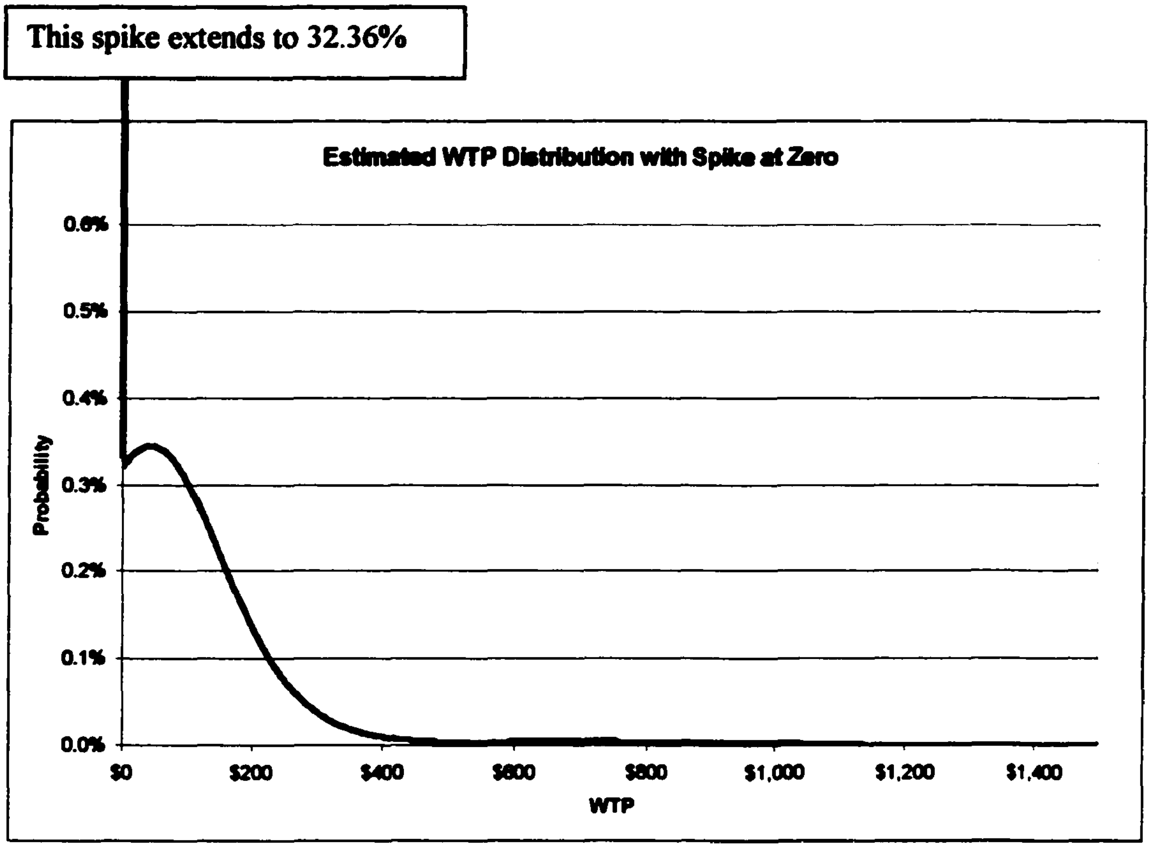
This function was evaluated from zero to two thousand. The graph below show the kernel density estimate for WTP values at the KRP. For comparison purposes, the figure below also includes the probability density function for a normal distribution centered on $\overline{X}'\beta$ and with a standard error of $\sigma e^{\overline{G}'\gamma}$. This censored normal distribution was also scaled, so that the integral over positive WTP equals one. Note that the kernel density estimate maybe the preferred estimate because it includes observations that were dropped from the regression during the list wise deletion process.

Graph 3.8, Estimated WTP Distribution



An alternative suggestion for estimating the distribution of WTP bids, was to assign all the probability that the kernel density estimate placed on negative WTP values to zero. This causes a spike that extends up to 32.36%, in the probability distribution at zero.

Graph 3.9, Estimated Distribution with Spike



3.6 KRP CVM Conclusions

The results of this CVM study are consistent with the results found in similar studies. The regression coefficients verify CVM's construct validity. That is, the coefficients indicate that WTP responds to changes in socioeconomic variables as predicted by general microeconomic theory. However, the regression results also indicate poor reliability. The model's standard error is quite large, resulting in a 95% confidence interval for expected WTP of $63.80 to $82.85 for the mean observation.

For use in a cost benefit framework, the expected WTP of $73.32 can be used to calculate an aggregate value of preserving the KRP. If the aggregation is applied to the

6,500 visitors in 1999 (although there may be non-use befits associated with the KRP that would be derived by non-visitors), the annual benefits are $476,580. The results of this study could also be used in a meta-analysis of non-market values, or for benefit transfer as will be tested in Chapter 5.

Chapter 4

4. Tanque Verde Wash Hedonic Study

This chapter presents a second non-market technique. The hedonic property price method is used to estimate the value of another area of riparian habitat in the arid southwest. This time the resource is the Tanque Verde Wash in Tucson Arizona, and the hedonic property price method is used to estimate its value. The regression analysis produced a price elasticity estimate of -.0451 for distance from the Tanque Verde. This elasticity implies that the expected sales price for homes falls .0451% for a 1% increase in distance from the Tanque Verde.

4.1. Introduction

When groundwater pumping occurs it creates a cone of depression in the water table around the well. If this cone overlaps riparian areas, or ephemeral[19] streams, it may result in significant damage to the ecosystem. In an attempt to preserve the few remaining riparian areas, and ephemeral streams in Arizona, the Governor's Water Management Commission has proposed a list of watercourses where no new wells would be permitted within a quarter mile. Using the hedonic property price method, this chapter presents the economic value of one of these listed watercourses, the Tanque Verde Wash in Northeast Tucson.

In the Tucson basin of southern Arizona the existence of large native trees is a rare treat. Cacti and small desert shrubs, the only flora able to survive the arid conditions

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[19] Ephemeral streams are waterways that flow only in response to a precipitation event.

dominate the landscape. However, in certain areas along ephemeral streams large stands of obligate species such as cottonwoods and willow trees still thrive, and provide a valuable environmental amenity to near by landowners. One such area is along the Tanque Verde Wash. Here homeowners enjoy scenic views of the wash, increased interaction with wildlife, and a buffer from the normal noise and pollution of a modern city. This is in contrast to much of Tucson, which suffers from staggering urban sprawl and high-density development. The unique amenity of the Tanque Verde wash creates a non-market benefit to those who enjoy it.

This chapter utilizes the oldest non-market valuation technique, the hedonic property price method. The independent variables are the normal factors that one would expect to have influence on a home's price (age, living space, lot size, etc.). In addition, variables representing the proximity to the Tanque Verde are included with the purpose of identify their marginal value to homebuyers.

4.2. The Data

Staff of the Arizona Department of Water Resources provided data for this study. It was generated using the Pima County's Geographical Information System (GIS), and included information about all parcels within 2.5 miles of the listed stretch of the Tanque Verde Wash. The northeast corner of Tucson, where the Tanque Verde is located, is one of the nicer areas of town, with modern infrastructure, good schools, upscale shopping areas, and scenic views of the Catalina and Santa Rita Mountains. For the Hedonic regression, only observations for single family, residential properties that were sold between 1996 and 1999 were used. Only the most recent four years of data were used due to the expectation that the hedonic price function is not stable over time, and that the inclusion of old data could bias estimates of the current hedonic price function. However, limiting the data to only 1999 would restrict the number of observations. The four year time span was selected as a compromise between the inclusion of old data and the desire for a larger number of observations. After final filtering, the data set contained 7719 observations.

The dependent variable used in the hedonic regression was the actual sale price of the homes. The county assessor's appraised value for the entire data set of approximately 25,000 homes was also available. But this measure of home value was eschewed in favor of the sale prices due to the possibility of biases in the assessed values.

The independent variables used to explain variation in the sale price of homes included 4 dummy variables (one for each year of sale), 5 structural variables, and one environmental variable. As noted, hedonic price functions normally includes independent variables describing the neighborhood. However, the sample in this regression displayed homogeneous neighborhood characteristics. This caused variables such as neighborhood ethnicity, mean education, crime rate, property tax rate, and so on, to be dropped from the model. The dummy variables representing year of sale were included to capture changes in housing market over time. Mahan, Polasky, and Adams also used observations from multiple years but were able to adjust prices to a baseline year using a publicly available local housing price index. No such measure was available for the Tucson area, so the dummy variables were used as a second best alternative. For the structural characteristics of the homes, the data set contained 16 or so descriptive variables. All but 5 of these were dropped, due to multicollinearity, and insignificant explanatory power. Finally, only one variable (distance to Tanque Verde) was used to describe the environmental characteristics of the home site. This was due to environmental homogeneity within the sample, and lack of data describing other site-specific environmental amenities.

The data was filtered for suspect observations by sorting the set by each variable in turn, and inspecting for extreme values.[20] The Table 4.1 below provides a summary of variable definitions, and summary statistics.

[20] For example, dropped from the data set were 5 observations that listed the area of the land parcel to be under 200 square feet, another 10 listed zero bathroom fixtures, and one observation indicated that the home had 200 garaged parking spaces.

Table 4.1. Hedonic Variable Definitions & Summary Statistics

Variable Name	Description
Dependent Variable	
SALE_AMT	Sale price of home.
Independent Variables	
DUMMY96	Binary dummy variable representing a 1996 home sale.
DUMMY97	Binary dummy variable representing a 1997 home sale.
DUMMY98	Binary dummy variable representing a 1998 home sale.
DUMMY99	Binary dummy variable representing a 1999 home sale.
AREA	Area of land parcel, measured in square feet.
TOT_LIVE	Total living space of home, measured in square feet.
AGE	Age of home at time of sale, in years.
BATH_FIX	Number of bathroom fixtures (toilets,sinks,showers,etc).
GARAGE	Number of garaged parking space.
DISTANCE	Distance to Tanque Verde, in miles.

Summary Statistics

Variable Name	Mean	Std. Dev.	Min	Max
SALE_AMT	181,336	108,304	28,000	1,855,584
AREA	23,686	56,723	2023	3,606,709
TOT_LIVE	2,041	680.8	374	7,765
AGE	15.61	14.87	0	98
BATH-FIX	7.76	2.49	2	21
GARAGE	1.53	1.11	0	6
DISTANCE	.847	.594	.1	2.5

	Number of Observations
DUMMY96	1608
DUMMY97	1847
DUMMY98	2353
DUMMY99	1911
	7719

4.3. Hedonic Model Estimation

The choice of a functional form for the hedonic price function was based on Cropper, Deck, and McConnell (1988), who used Using Monte Carlo simulations to study the effects of various hedonic price function specifications on parameter estimates. They reached the conclusion that, in practical applications, simple forms such as linear, semi-log, double log and Box-Cox, perform the best. Linear, log-linear, linear-log, and double log specifications were modeled with the Tanque Verde data set. A comparison of the performance of the alternate functional forms is presented in appendix B. All of the alternate specifications performed well, but the double log alternative resulted in the best fit, and the most precise estimate for the coefficient of DISTANCE. The double-log, hedonic price function used was:

$$\ln\text{SALE\_AMT} = \beta_1\text{DUMMY96} + \beta_2\text{DUMMY97} + \beta_3\text{DUMMY98} + \beta_4\text{DUMMY99} + \beta_5\ln\text{AREA} + \beta_6\ln\text{TOT\_LIVE} + \beta_7\text{AGE} + \beta_8\ln\text{BATH\_FIX} + \beta_9\text{GARAGE} + \beta_{10}\ln\text{DISTANCE} + \varepsilon$$

Note that in the function above, not all of the independent variables have been transformed with the natural log operator. Only the variables that did not contain an observation of zero were "logged", the others were left unchanged. The double log specification provides estimation of nonlinear relationships between the dependent variable and the regressors. This is appealing because there is an a priori expectation that the marginal effect on home price would not be constant with respect to distance to the Tanque Verde, and other housing characteristics.

Ordinary least squares regression was used to fit the equation. The results were then checked for heteroskedasticity using the Cook-Weisberg (Breusch-Pagan) test. The tests indicated heteroscedasticity of an unknown nature. To recover consistent estimates for the standard errors of the coefficients, White's (Huber's) method was used in a second regression the results of which are presented in Table 4.2.

Table 4.2 Tanque Verde Regression Results

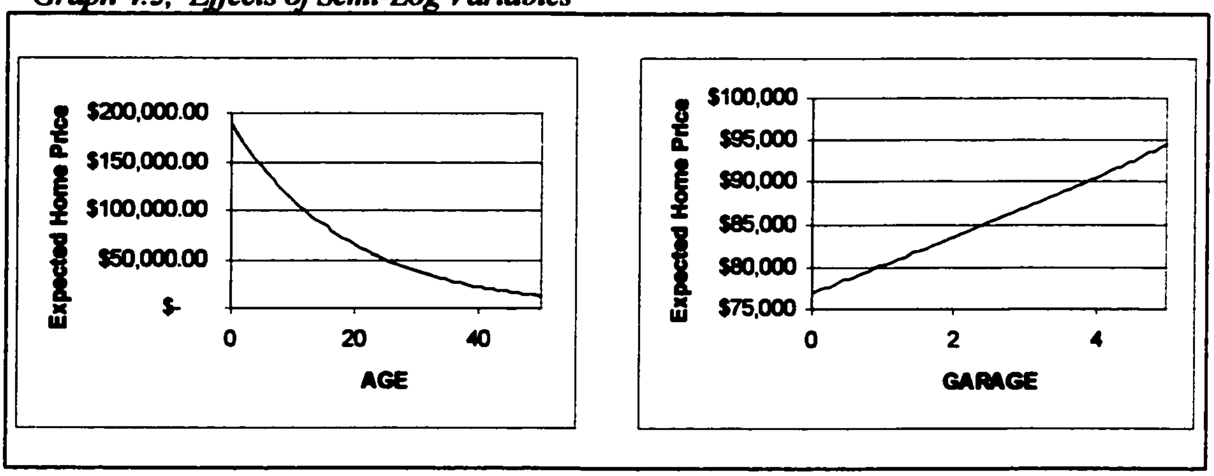
Variable Name	Estimated Coefficient	Standard Error	T-Stat	P-Value
DUMMY96	4.76722	0.082046	58.461	0
DUMMY97	4.78593	0.081832	58.849	0
DUMMY98	4.82262	0.082171	57.061	0
DUMMY99	4.8965	0.082623	57.655	0
lnAREA	0.17013	0.003804	43.764	0
lnTOT_LIVE	0.70296	0.015000	46.53	0
AGE	-0.0535	0.000266	-20.789	0
lnBATH_FIX	0.11325	0.014287	7.409	0
GARAGE	0.04095	0.003301	11.637	0
lnDISTANCE	-0.0451	0.002414	-18.757	0

R-squared: 0.83694

The R-squared (the co-efficient of multiple correlation), measures the proportion of the total variation in the independent variable that can be explained by the linear combination of regressors (Johnston & DiNardo 1997). A brief review of 6 studies, that estimated hedonic price functions using ordinary least squares, revealed an average R-squared of .722, with a range of .4148 to .939. The R-squared measure of .83694 for the Tanque Verde regression, indicates that the double-log hedonic price function was adequate predictor of home prices in 1996 through 1999. The T-stats and P-values demonstrate the accuracy of the estimated coefficients. All coefficient estimates are significant at the 5% level, a common benchmark for evaluating significance. At the sample means, the expected sale price is $162,502[21], with a 95% confidence interval of plus or minus $665.

With a linear specification the hedonic price function's coefficients can be interpreted as marginal implicit prices for a home's various amenities. However, with the double-log specification used here, the interpretation of the coefficients is a little more complicated. For the independent variables that were not transformed (AGE & GARAGE), the regression coefficients have the same interpretation as they would in a semi-log specification. That is, the coefficients are the ***proportionate*** change in home price ***per unit*** change in the independent variable (Johnston & DiNardo 97). That is: $\beta_I = (1/Y)(\partial Y/\partial X_I)$. The following graphs are provided to illustrate the effects of AGE and GARAGE on home price.

Graph 4.3, Effects of Semi-Log Variables



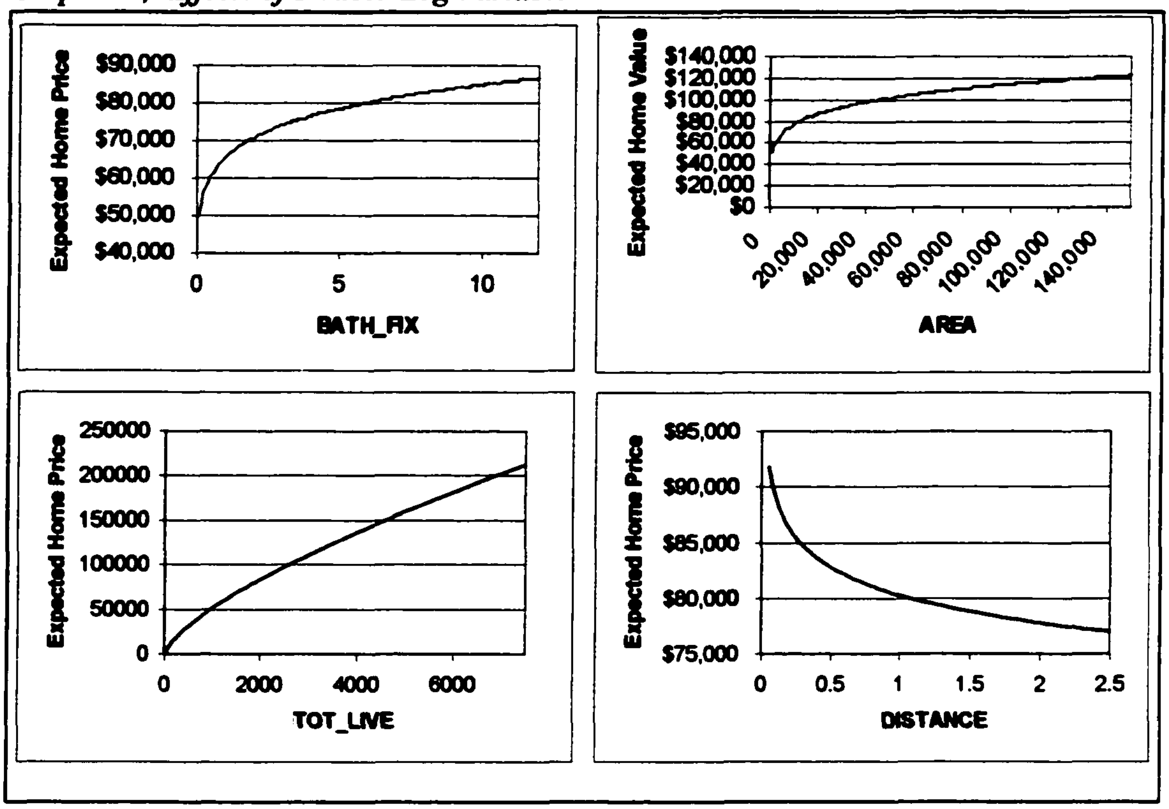
As expected, age decreases, and number of garages increases the expected value of the home. Although it seems unlikely that an age of 25 would drive the average homes value to below $50,000, as the graph indicates. One possible explanation is that a

[21] Note that the expected sale price at the sample mean is different from the mean sale price of homes from the sample because of the non-linear transformation of sale price. The mean of lnSALE is 11.9984, which is equal to $162,495.

majority of the observations listed ages lower that 20, perhaps implying that the graph above is more relevant over the initial range of newer homes.

For the independent variables that have been transformed with the natural log operator, the coefficients can be interpreted as elasticities. Elasticity measures the percentage change in a home's price for a 1 percent change in one of the "logged" variables. That is: $\beta=(\partial Y/\partial X)(X/Y)$. The coefficient estimates associated with parcel size, total living space, number of bathroom fixtures, and distance to the Tanque Verde are all elasticity estimates. To illustrate the effects of these variables, each has been graphed with respect to home price.

Graph 4.4, Effects of Double-Log Variables



Both size of land parcel, and number of bathroom fixtures display positive, but decreasing marginal implicit prices, as one might expect. While the marginal implicit price for living space is almost constant. But of greatest interest is the effect of distance to the Tanque Verde, which has a negative impact on home price, but at a diminishing rate. The chart above shows how homes that are in close proximity (within 1 mile) to the wash are priced at a considerable premium, compared to those farther out. Following the methodology of Mahan, Polasky and Adams the marginal implicit price for reducing the distance to the Tanque Verde by 1,000ft, evaluated at the mean home value, and an initial distance of one mile, was calculated to be $1,698.

As noted earlier the partial derivative of the hedonic price function, with respect to any of the variables, gives the marginal implicit price for that characteristic (Freeman 1993). The Table 4.5 shows the marginal implicit prices for each variable in the price function, evaluated at the sample mean.

Table 4.5. Marginal Implicit Prices

Variable	Marginal Implicit Price	
AREA	$ 1.00	per sq. ft.
TOT_LIVE	$ 29.76	per sq. ft.
AGE	$ (4,387.32)	per year
BATH_FIX	$ 1,260.65	per fixture
GARAGE	$ 3,356.27	per garaged parking space
DISTANCE	$ (5,862.95)	per mile

The marginal implicit price of the Tanque Verde riparian corridor is positive and increases with proximity. Also, it is roughly four times the amount estimated by Mahan, Polasky, and Adams. This is understandable considering the number of substitute wetlands available in Portland Oregon (approximately 4,500), versus the number of substitute ephemeral streams in the Tucson basin (less than 100).

4.4 Value Aggregation

To make these results more useful to policy makers, it's necessary to calculate some aggregate measure of the non-market benefits of the Tanque Verde riparian corridor. Such an aggregate measure could be used in a cost benefit analysis of the Governor's Water Management Commission's proposed ban on new groundwater wells, along the Tanque Verde Wash.

For this study two different approaches were used to estimate aggregate value. The first involves an attempt to estimate the marginal willingness to pay function for a representative consumer, followed by the calculation of Marshalian consumer surpluses for all home owners. The second approach calculates the difference between the expected value of the homes in the data set and what their expected values would be if the positive effects of proximity to the Tanque Verde were removed.

4.4.1 Aggregation Using Marginal Willingness to Pay Estimate

Measurements of non-market benefits are commonly based on consumer surplus estimates based on marginal willingness to pay (demand) functions. But thus far, this study has only produced point estimates where marginal willingness to pay equals the marginal implicit price for proximity to the Tanque Verde. Rosen (1974) suggests a procedure for rough estimation of consumer demand functions. He suggests computing the marginal implicit price for each observation in the data set, then using them as endogenous variables in a second-stage estimation of a consumer demand function (Rosen 1974). Many have criticized this method as fraught with problems of identification. Rosen and Brown (1982) (A different Rosen) argued that:

> "In the absence of additional restrictions, second-stage "structural" estimation of the sort suggested by Rosen may only reproduce the information already provided by the first stage estimation of the hedonic price function" (Rosen & Brown 1982, p 312).

Freeman (1993) suggested that an improved estimation of demand functions could be achieved with the use of data from segmented markets. However, the area represented in the Tanque Verde data set is a homogeneous market. Thus Freeman's method can not be used here. So, despite its shortcomings, the following marginal willingness to pay function, for proximity to the Tanque Verde Wash is estimated, using Rosen's (1974) method.

For each observation in the data set the estimated marginal willingness to pay was calculated to be ($\beta_{lnDISTANCE}$ X AMT_SALE) ÷ DISTANCE. This was used as the dependent variable in an ordinary least squares regression upon DISTANCE, using a double-log specification.

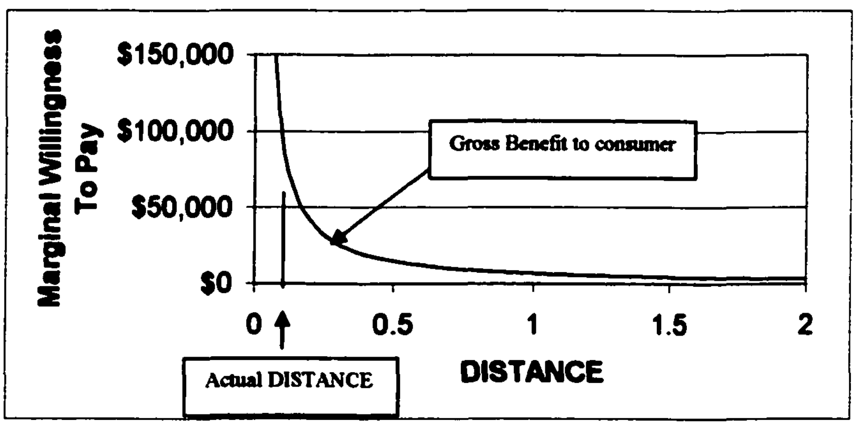
Table 4.6. MWTP Regression Results

Variable Name	Estimated Coefficient	Standard Error	T-Stat	P-Value
Constant	8.83283	.005842	1511.9	0.00
lnDISTANCE	-1.12545	.006158	-182.74	0.00

R-squared: 0.8123

Using these results as the marginal willingness to pay function, the gross benefits for all homes within one mile of the Tanque Verde riparian corridor, and sold between 1996 and 1999, were calculated to be the integral from the actual distance of the home to the one and a half mile mark[22]:

Graph 4.7, MWTP Curve



[22] The selection of one and a half mile as a baseline was selected somewhat arbitrarily. A point needed to be chosen as a bound for the benefit integral, due to the asymptotic nature of the marginal willingness to pay function. 1.5 miles is a conservative choice, resulting in relatively low benefit estimates.

Given the benefit definition above, the aggregate gross benefits of the Tanque Verde for homes within one mile can be written as follows:

$$\sum_{i=1}^{N}\left(\int_{DIST_i}^{1} MWTP(DIST)dDIST\right)$$

N: Number of homes located within 1.5 mile of the Tanque Verde.
$DIST_i$: DISTANCE to Tanque Verde for the *ith* home.
MWTP: Marginal Willingness to Pay, as estimated above.

Because this aggregation method relies only on the variable DISTANCE, it can be applied to the entire Tanque Verde data set of 25,329 homes with a DISTANCE of less than 1.5. resulting in an aggregate estimate of $193,939,909.

4.4.2 Aggregation Directly from the Hedonic Price Function.

The second method use to aggregate the value of the Tanque Verde is based upon an estimate of the capitol loss that home owners would incur should the benefits of the wash be removed. This was done by estimating the value of all 25,329 homes using our hedonic price function. Then the values were re-estimated under the condition that the value added by the Tanque Verde was practically zero. As was done in the first method, the one and a half mile point for the variable DISTANCE was chosen as the proxy for a point where the Tanque Verde's benefits become approximately zero. This method produced an estimated aggregate value of $232,255,571 for the Tanque Verde.

The relative closeness of the two aggregation methods shouldn't be surprising due to the fact that the marginal willingness to pay function used in the first method, is derived from the hedonic price function used in the second method.

4.5 Conclusion

The double log specification of the hedonic price function was a good fit for the Tanque Verde data set, resulting accurate estimation of the riparian corridor's effect on housing prices. The results derived in this chapter contribute to the debate over the preservation of riparian habitats, by quantifying the effects of one of these areas on housing values. The Tanque Verde data set will also be used to in the next chapter on benefit transfer.

Chapter 5

5. Benefit Transfer

This chapter investigates the validity of benefit value transfer (BVT) and benefit function transfer (BFT), using the Kern River CVM from Chapter 3, and two additional CVMs presented in section 5.1 below. An extended investigation of temporal BVT using the Tanque Verde data set is presented in section 5.6.

Benefit transfer is defined as "the transfer of existing estimates of non-market values to a new site which is different from the site for which the values were originally estimated" (Boyle & Bergstrom 1992: p. 657). Following the common benefit transfer terminology, the site <u>from</u> which estimates will be transferred is termed the *study site*, and the site <u>to</u> which estimates are to be transferred is termed the *policy site*.

The demand for value estimates of non-market resources has increased in response to new regulations that call for cost benefit analysis of environmental laws, and land use decisions. However, the time and monetary requirements of performing a quality CVM study can be quite high. To avoid these costs, many are utilizing benefit transfer techniques as second best alternatives. Therefore it is important to test the reliability of these techniques to identify the most appropriate methods.

5.1 San Pedro River CVMs

For the purpose of investigating benefit transfer techniques, additional non-market studies are required. Two CVM studies of the San Pedro Riparian National Conservation Area (San Pedro RNCA) in southern Arizona were performed here at the University of

Arizona. These two studies, along with the KRP CVM will be used as study and policy sites in analysis of benefit transfer techniques.

The San Pedro River is located in southern Arizona, and shares many ecological features with the Kern River. Its unique riparian habitat depends on perennial stream flows, it has been recognized as a globally important birding area, its ecosystem is characterized by cottonwood and willow trees, and the area is open to the public for hiking, birding, picnicking, and other environmentally friendly activities. However, at 56,000 acres, the San Pedro RNCA is approximately fifty times the size of the KRP and attracts many more visitors annually (Kirchhoff 1994).

5.1.1 Kirchhoff, Colby, & LaFrance 1997

The first study, Kirchhoff, Colby, & LaFrance (1997) administered CVM surveys in 1992. The survey used a WTP payment card elicitation format, with the hypothetical situation that a non-profit organization was being created to maintain the riparian habitat for the purpose of protecting the endangered Gray Hawk. As with the KRP, the baseline environmental status is the diminished state, because the hypothetical situation stipulates that without sufficient funding to the non-profit organization the San Pedro's riparian habitat will be damaged to the extent that the Gray Hawk will no longer be found in the area. This implies that compensating surplus (CS) is the welfare measure being investigated.

The data set consisted of 170 observations after list wise deletion and removal of protest bids. The authors specified a heteroskedastic Tobit model to fit the data. Regression results[23] are presented in Table 5.1

Table 5.1, 1997 San Pedro Regression Results

	Coefficient	Standard Error	T-Stat
Regression Function			
Constant	162.0690	107.12	1.513
INC	-6.0940	4.919	-1.239
INC^2	0.2905	0.2004	1.449
lnAGE	-33.4579	24.48	-1.367
EDU	2.5833	2.8	0.923
PRVTRPS	0.0335	7.0216	0.005
PRVTRPS^2	-0.4000	0.5957	-0.671
FOREIGN[24]	-21.2993	16.127	-1.321
MAINREAS**	78.1274	22.3922	3.489
Heteroskedastic Function			
INC**	-0.07813	0.0364	-2.143
INC^2*	0.00257	0.0014	1.782
lnAGE*	-0.4456	0.2676	-1.665
EDU**	0.09454	0.0229	4.133
PRVTRPS**	0.4597	0.1397	3.289
PRVTRPS^2**	-0.1803	0.0348	-5.170
FOREIGN**	-1.0246	0.2433	-4.211
MAINREAS**	1.2312	0.1329	9.267
Sigma	161.48	187.515	0.861
Log-likelihood	-916.89		
Mean WTP	81.69		
E[WTP]	82.26		

* Significant at the 5% level
** Significant at the 10% level.

All of the regression coefficients are of the expected sign, except for PRVTRPS and its square. For this variable the first derivative of the bid function is negative. Only

[23] The regression was run using the same functional form. But, results in Table 3.7 differ slightly from those presented in Kirchhoff, Colby, & LaFrance (1997), due to slightly different transformation of variables and different convergence criteria for log-likelihood function maximization.

[24] FOREIGN is a dummy variable equaling one if the respondent is not a citizen of the United States

one of the regression coefficients passes a test for significance. This may be a result of multicollinearity within the explanatory variables.

5.1.2 Orr & Colby 2001

The second CVM performed at the San Pedro RNCA had its surveys administered in 2001. The survey was very similar to the KRP and 1992 San Pedro surveys. It used a payment card elicitation format, and contribution to a nonprofit group as the payment vehicle. The data set contained 551 observations, and the author specified a heteroskedastic Tobit as the functional form. The regression results are presented in

Table 5.2, 2001 San Pedro Regression Results

	Coefficient	Standard Error	T-Stat
Regression Function			
Constant	-30.89	100.787	-0.307
lnINC**	22.76	8.359	2.723
EXPENDITURE**[25]	0.5527	0.212	2.604
REPEAT_VISIT**[26]	37.29	15.655	2.382
lnAGE**	-53.13	26.332	-2.018
lnDAYSBIRDING[27]	5.103	3.951	1.292
ECO	-0.4961	14.477	-0.034
Heteroskedastic Function			
lnINC**	0.2156	0.0448	4.8140
EXPENDITURE**	0.0064	0.0005	13.9970
REPEAT_VISIT**	0.3433	0.0424	8.0920
lnAGE*	-0.1665	0.0954	-1.7460
lnDAYSBIRDING**	0.0668	0.0148	4.5030
ECO**	0.2251	0.0657	3.4250
Sigma	8.681762	5.625247	1.543
Log-likelihood	-3121.04		
Mean WTP	$86.50		
E[WTP]	$98.88		

* Significant at the 5% level
** Significant at the 10% level.

[25] The variable EXPENDITURE is the respondent's average daily expenditure in the Sierra Vista area.

[26] REPEAT_VISIT is a dummy variable that equals one if the respondent had made previous trips to the San Pedro RNCA.

[27] The DAYSBIRDING variable represents the number of days in the past year that the respondent spent birding.

With this model all of the variables are of the expected sign, except possibly the ECO variable. It's not clear whether membership to an environmental organization should have a positive or negative effect on WTP. This statement is supported by ECO's very low T-stat, which indicates that the regression does not give conclusive evidence for the sign of ECO either way. The 2001 Orr & Colby model has many coefficients that pass significance tests.

Ideal conditions for benefit transfers involving CVM studies include the use of identical survey instruments, and valuation of the same type of environmental change (Bergland et. al. 1995). These conditions are not met using the KRP, and the two San Pedro CVMs. The studies differ in various ways. But the most significant differences are: 1) The KRP survey elicits WTP as a regular annual contribution, while the San Pedro surveys both elicit a one time contribution. 2) The 1992 San Pedro survey couches the preservation of stream flows as way to protect the endangered Gray Hawk. The other two surveys do not mention the preservation of any one species in particular, but propose the protection of the entire ecosystems surrounding the respective rivers, via the preservation of stream flow levels. However, the three surveys all concern riparian habitat located in arid climates, they all use WTP for environmental improvement, and they all use contributions to non-profit organizations as the hypothetical payment vehicle. Therefore, the conditions for benefit transfer among these three studies are good, but not ideal.

5.2 Benefit Value Transfer

The simplest approach to benefit transfer is the Benefit Value Transfer technique. This technique transfers unadjusted benefit estimates from the study site, to the policy site. While its simplicity makes it attractive, there are good reasons to believe that non-market benefits are not equal at policy and study sites. These reasons include differences in the socio-economic characteristics of the relevant populations, and differences in the physical characteristics of the sites (Bateman et. al. 2000).

However, before proceeding any further it is necessary to adjust the WTP estimates from the KRP and the 1992 San Pedro studies so that they conform to the WTP values from the 2001 San Pedro.[28] As noted earlier the KRP CVM elicited WTP values as annual contributions, while the San Pedro CVMs elicited values as one time (lump sum) contributions. The literature does not provide any specific guidance on reconciling these two contribution formats. Consequently, the adjustment was left to the intuition of the researcher.[29] To adjust for the difference between annual and lump sum contributions, WTP values from the KRP were assumed to represent the respondents WTP for the next three years. This value was discounted to present value using a 5% discount rate. The decision to extend the annual WTP values to only a three year horizon was based on the belief that consumers are limited in their ability to estimate their budget constraints, and their preference structures much beyond their current status. This adjustment increased mean WTP at the KRP from $76.56 to $218.92. If the WTP values from the KRP had not been adjusted, the tests of benefit transfer involving these values

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[28] The 2001 San Pedro was selected as the baseline WTP measure due to the high quality of the study. However, either of the other two studies could have been selected as the baseline.

[29] Results for benefit transfer tests using unadjusted KRP WTP values are presented in appendix D.

would have to be judged invalid. This is because the tests would be comparing incongruous measures of compensating surplus. Although the adjustment made was subjective in nature, it at least has the possibility of being correct and producing valid benefit transfer tests.

The 1992 San Pedro WTP values needed to be inflated to 2001 dollars to facilitate comparison to the new San Pedro study. The Consumer Price Index (CPI) for the entire U.S. was selected as the inflation factor. The national CPI was selected in preference to a state or regional index, due to the geographically diverse residences listed by survey respondents. As a result of this adjustment the mean WTP from the 1992 CVM increased from $81.70 to $103.18. The mean WTP for the 2001 San Pedro study was $86.34.

An interesting aside here is that looking at the mean WTP estimates at the KRP and at the San Pedro, it does not appear bid amounts are responsive to the scope of the environmental change. The San Pedro riparian conservation area is over fifty times the size of the KRP, the expectation is that people should be willing to pay more for the conservation of a larger area of land. However, the data from these two site indicate that the willingness to pay is higher for the smaller site.

To investigate the veracity of BVT involving our three CVMs, two alternate validation criteria were selected. First, is the Wilcoxon rank sum test[30], a non-parametric test for differences in the location (mean) of two distributions. This test is preferred to the *t*-test, due to the fact that the *t*-test assumes that the WTP amounts are drawn from a

[30] A complete treatment of the Wilcoxon test and the rest of the econometrics for BVT are presented in Appendix E.

normal distribution[31] (Brouwer & Spaninks 1999). Using our three CVM studies, there are three alternate BVT hypotheses to be tested, each one representing a different type of BVT; temporal, spatial, and spatial & temporal combined. Table 5.3 summarizes the three null hypotheses.

Table 5.3, BVT Null Hypotheses

	Null Hypothesis	BVT Type
1.	H_o: $\overline{WTP}_{KRP} = \overline{WTP}_{SP01}$	Spatial
2.	H_o: $\overline{WTP}_{SP92} = \overline{WTP}_{SP01}$	Temporal
3.	H_o: $\overline{WTP}_{SP92} = \overline{WTP}_{KRP}$	Spatial & Temporal

Abbreviations:

$\overline{WTP}$ =Mean willingness to pay
KRP=Kern River Preserve
SP92= San Pedro 1992, Kirchhoff
SP01= San Pedro 2001, Orr

The results of the Wilcoxon test indicate that centers of the WTP distributions are statistically different at the study and policy sites for the spatial and the spatial/temporal combined transfers, and the same for the temporal transfer. Table 5.4 summarizes the results of the Wilcoxon test.

Table 5.4, Results of Wilcoxon Rank Sum Test

	Null Hypothesis	Wilcoxon Test Statistic	2-Tailed P-Value[32]	Test Result
1.	H_o: $\overline{WTP}_{KRP} = \overline{WTP}_{SP01}$	6.96	<0.001	Reject
2.	H_o: $\overline{WTP}_{SP92} = \overline{WTP}_{SP01}$	-0.055	0.96	Fail to Reject
3.	H_o: $\overline{WTP}_{SP92} = \overline{WTP}_{KRP}$	-4.88	<0.001	Reject

[31] Given the truncated nature of WTP values, the assumption of a normal distribution is clearly violated.
[32] The 2-tailed p-value indicates the probability that the null hypothesis of equal mean WTP is true.

The second test follows the procedure outlined by Kirchhoff et. al. (1997). The test criteria is based on whether or not the expected WTP for the study site falls within the estimated 95% confidence interval for expected WTP at the policy site, and vice versa. The formal statement of the test criteria is:

1) $E[WTP_{study}] \in CI_{95\%policy}$ [33]
2) $E[WTP_{policy}] \in CI_{95\%study}$

If both conditions are met the null hypothesis is not rejected, and the BVT is judged to be valid. If one condition is satisfied and the other is not the result is ambiguous. If both conditions are not met the null is rejected, and BVT is judged to be invalid (Kirchhoff et al. 1997). The delta method was used to calculate the confidence intervals for expected WTP, a description of this method, and the equation used to calculate expected WTP are presented in Appendix D. Table 5.5 lists expected WTP and the corresponding 95% confidence interval for each CVM study.

Table 5.5 Expected WTP & Confidence Intervals

CVM Study	E[WTP]	$CI_{95\%}$
San Pedro 1992	\$107.73	\$87.73 ⇔ \$127.72
San Pedro 2001	\$98.88	\$85.28⇔ \$112.49
KRP	\$209.78	\$182.50⇔ \$237.05

Based on the results in Table 5.3 the null hypothesis of equal expected WTP at the study and policy sites can be tested using Kirchhoff's method of confidence intervals. The result of the tests, along with the percentage difference between expected WTP at the study site and policy site, are presented in Table 5.6

Table 5.6 Results of Kirchhoff's Confidence Interval Test

Null Hypothesis	% Difference	Test Result

[33] $CI_{95\%}$ is the 95% confidence interval around E[WTP] for the site specified.

1.	H_o: $E[WTP_{KRP}]=E[WTP_{SP01}]$	-52.9%	Reject
2.	H_o: $E[WTP_{SP92}]=E[WTP_{SP01}]$	-8.2%	Fail to Reject
3.	H_o: $E[WTP_{SP92}]=E[WTP_{KRP}]$	94.7%	Reject

The Kirchhoff criteria rejects the validity of both spatial and spatial/temporal combined BVT. However, does not reject the temporal transfers. These results are in line with expectations. While the Kern River Preserve and San Pedro RNCA both represent desert riparian habitats, they feature some what different habitat and species, and are in different locations. Therefore we might expect that WTP values are different in these areas. With respect to the temporal transfer, it's not clear whether the a priori expectation is for an increase or decrease in the mean WTP over time. One could perhaps argue that the number of substitute sites has decreased over that time, due to rapid development in the area. On the other hand the water flows in the San Pedro have decreased over the past nine years due to increased competing water uses in the area. The fact that the Wilcoxon test, and the Kirchhoff criteria produce the same conclusions regarding the validity of BVT strengthens the results.

5.3 Testing Benefit Function Transfer

Validity of BVT depends on the assumption that the value of the study site is equal to that at the policy site. But as noted earlier, there are usually differences both physical and socioeconomic, between the sites and their relevant populations. The method of benefit function transfer was developed as a way to account for at least some of these differences. With BFT the coefficients from the study site's WTP function are transferred to the policy site, and used with the socioeconomic data from the policy site's relevant population. In this way BFT is able to transfer more information about the expected value of an environmental amenity than can BVT. However, because CVM studies are almost exclusively based on a single environmental amenity, a single indicator of environmental quality, and use a single elicitation format, estimated WTP functions normally contain no coefficients that represent the physical characteristic of the site, nor methodological issues relating to the primary survey. Therefore the BFT technique adjusts for some of the differences between study and policy sites, but perhaps not the most important differences (site physical characteristics, site quality, methodological issues).

When testing the validity of BFT, Bergland et. al. (1995) suggests two possible approaches. The first approach uses the supposition that the regression coefficients estimated at the study site are the true coefficients, and that the coefficients estimated for the policy site should be the same. This leads to the following hypothesis:

$$H_o: \beta_{study} = \beta_{policy}$$

The second approach assumes that the data from the study and policy sites comes from the same population, and that coefficients estimated at both sites should equal those from the entire population. This assumption is tested by pooling the data sets to estimate the population coefficients, then testing for equality to the coefficients at the policy and study site.

$$H_o: \beta_{population} = \beta_{study} = \beta_{policy}$$

This hypothesis is the weaker of the two as it tests for consistency between the parameters for the two sites, and does not assume that the study site coefficients are the true coefficients (Bergland et. al. 1995).

Only the first approach to testing BFT will be investigated using the two San Pedro, and the KRP CVMs. Kirchhoff's method of confidence intervals and Wald tests[34] will be used to test for equality of WTP functions. The second null hypothesis that investigates equivalence with the population coefficients is not pursued here as it is the less restrictive hypothesis, and because the pooled model presented in Chapter 6 investigates a similar hypothesis.

5.4 $\beta_{study} = \beta_{policy}$

When using BFT, the functional form for the WTP function (by definition) comes from the study site. For the temporal, and the combined spatial/temporal transfers the functional form will come from the 1992 San Pedro CVM, as it is the study site in both cases. However for the spatial transfer, the functional form may come from the KRP or the 2001 San Pedro CVMs, as they both may be defined as the study site. A review of the relevant literature found no published studies that utilized multiple functional forms in conjunction with a single set of sites for investigation of BFT. The spatial transfer will be investigated first, followed by the temporal and the combined transfers.

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[34] Likelihood Ratio, and Chow tests have also been used. But these tests are not recommended, as they test for the equality of explained variance, not necessarily the equality of estimated coefficients (Brower & Spaninks 1999)

5.4.1 $\beta_{study} = \beta_{policy}$ Spatial

The first step in evaluating spatial BFT is to estimate the WTP function for the policy site, using the functional form from the study site. Table 5.7 presents the regression results for the 2001 San Pedro data using the KRP specification presented in chapter 3, and vice versa.

Table 5.7, Regression Results for Spatial BFT

KRP Specification

$$WTP = \beta + \beta PRVTRPS + \beta EDU + \beta \ln INC + \beta AGE^2 + \sigma e^{(\gamma ECO + \gamma GENDER + \gamma BIRD)}$$

	KRP Data		2001 San Pedro Data	
	Coefficients	P-values	Coefficients	P-values
Regression Function				
Constant	**-1120.89**	**0.010**	**-299.20**	**0.0107**
Previous Trips	**25.23**	**0.030**	**3.46**	**0.0011**
Education	**24.60**	**0.036**	**7.37**	**0.0141**
ln(Income)	76.19	0.059	**22.17**	**0.0294**
AGE^2	-0.0287	0.182	-0.006	0.2144
Heteroskedastic Function				
Member of Environmental Group	**0.980**	**0.0000**	**0.554**	**0.0000**
Gender	**-0.777**	**0.0000**	**-0.173**	**0.0000**
Birder	**-0.903**	**0.0000**	**-0.310**	**0.0000**
σ	**429.92**	**0.0000**	**126.47**	**0.0000**

2001San Pedro Specification

$$WTP = \beta + \beta \ln INC + \beta EXP + \beta REPEAT + \beta \ln AGE + \beta \ln BIRDDAYS + \beta ECO + \sigma e^{(\gamma \ln INC + \gamma EXP + \gamma REPEAT + \gamma \ln AGE + \gamma \ln BIRDDAYS + \gamma ECO)}$$

	2001 San Pedro Data		KRP Data	
	Coefficients	P-values	Coefficients	P-values
Regression Function				
Constant	-30.892	0.7592	107.78	0.6657
Ln(Income)	**22.764**	**0.0065**	10.27	0.6948
Expenditure per Day	**0.553**	**0.0092**	0.309	0.1361
Repeat Visitor	**37.294**	**0.0172**	43.79	0.1896
Ln(Age)	**-53.136**	**0.0436**	-50.40	0.3558
Ln(Birding Days per Year)	5.103	0.1965	2.57	0.8402
Member of Environmental Group	-0.496	0.9727	70.77	0.0998
Heteroskedastic Function				
Ln(Income)	**0.216**	**0.0000**	**0.7416**	**0.0000**
Expenditure per Day	**0.006**	**0.0000**	**0.0012**	**0.0000**

Repeat Visitor	**0.343**	**0.0000**	0.0627	0.4878
Ln(Age)	-0.167	0.0809	**-1.04**	**0.0000**
Ln(Birding Days per Year)	**0.067**	**0.0000**	**0.1286**	**0.0005**
Member of Environmental Group	**0.225**	**0.0006**	0.2771	0.0899
σ	8.682	0.1227	2.12	0.3439

Note: Coefficients that pass a test for significance at the 5% level are in bold font.

Both specifications yield estimates that differ greatly in magnitude, which is not surprising given the much larger WTP values in the KRP data set that resulted from the transformation from annual payment to a one time contribution. Next, BFT is tested for these two specifications using both Kirchhoff's method of confidence intervals, and the Wald test for equivalence of coefficients.

Directly analogous to the case of testing BVT, Kirchhoff's method for testing BFT requires that two conditions be met. First, is the condition that the predicted WTP at the policy site (predicted WTP is calculated by using the regression coefficients form the study site with the mean values for the socioeconomic variables at policy site), must fall within the 95% confidence interval for WTP at the policy site. The second condition states that the true expected WTP at the policy site must fall with in the predicted 95% confidence interval for the policy site (As with the predicted WTP, this confidence interval is calculated with the study site's coefficients and the policy site's means.). More formally these conditions are stated as follows:

1) $E[WTP_{BFT}] \in CI_{95\%Policy}$ [35]

2) $E[WTP_{Policy}] \in CI_{95\%BFT}$

[35] The subscript BFT indicates a value calculated using the benefit function transfer technique. This technique uses coefficients from the study site and variable means from the policy site.

Just as in the case of BVT if both conditions are met, BFT is not rejected. If only one is met the result is ambiguous. And if both are not met, BFT is rejected.

BFT is also tested using a Wald test, as suggested by Brower and Spaninks (1999). These authors noted that the Wald test directly tests for equality of coefficients, and has the advantage of not depending on the proportion of explained variance, as does the Likelihood ratio and the Chow tests. The Wald test statistic was calculated as follows.

$$W = (\beta_{policy} - \beta_{study})' \Sigma_{study}^{-1} (\beta_{policy} - \beta_{study})$$

Where β is a vector of the estimated regression, heteroskedastic, and standard error coefficients, and where Σ_{study} is the variance-covariance matrix estimated at the study site. Table 5.8 presents the results for testing the validity of BFT involving the KRP and the San Pedro 2001 CVMs, using Kirchhoff's confidence interval criteria, and the Wald test for equality of coefficients.

Table 5.8 Test Results for Spatial BFT

KRP Study Site & 2001 San Pedro Policy Site		Test Result
Kirchhoff Criteria		
$E[WTP_{BFT}]$ = \$203.14	$CI_{95\%Policy}$ = \$87.10⇔\$108.21	Reject BFT
$E[WTP_{Policy}]$ = \$97.66	$CI_{95\%BFT}$ = \$171.35⇔\$234.93	
Wald Test (Critical value = 16.92)		
W = 612.18		Reject BFT

2001 San Pedro Study Site & KRP Policy Site		Test Result
Kirchhoff Criteria		
$E[WTP_{BFT}]$ = \$176.22	$CI_{95\%Policy}$ = \$178.11⇔\$257.63	Reject BFT
$E[WTP_{Policy}]$ = \$217.87	$CI_{95\%BFT}$ = \$141.38⇔\$211.07	
Wald Test (Critical value = 23.68)		
W = 25,803		Reject BFT

For both specifications BFT is rejected. However, there is concern that the Wald tests were rejecting BFT mainly due to coefficient differences in the heteroskedastic term. If this were true, BFT may have been unfairly rejected, when it was actually the case that BFT was providing reasonable estimates of WTP at the policy site. Therefore, the Wald test was repeated, this time testing only for equality of the regression coefficients, excluding the heteroskedastic coefficients, and the estimated standard error coefficient, the W statistics fell to 31.25 and 145.09, for the KRP and 2001 San Pedro as the study sites, respectively. Both of these results rejected the null hypothesis of equality of regression coefficients, with the new critical values being 11.07 and 14.51 respectively. Consequently it can be safely concluded that BFT is invalid in this case.

5.4.2 $\beta_{Study} = \beta_{policy}$ Temporal and Combined

The method for evaluating the temporal and temporal/spatial combined transfer is much like the method used in the spatial case. The 1992 San Pedro will be specified as a study site, and the functional form specified by Kirchhoff et. al. (1997) will be used. Table 5.9 displays the regression results for all three sites, using Kirchhoff's specification.

Table 5.9, Regression Results for Temporal and Combined BFT

	1992 San Pedro		2001 San Pedro		KRP	
	Coefficients	P-values	Coefficients	P-values	Coefficients	P-values
Regression Function						
Constant	197.5	0.136	-14.22	0.899	86.7	0.705
INCOME	-4.16	0.491	2.19	0.194	-2.39	0.481
INCsq	0.222	0.360	-0.03	0.076	0.0452	0.331
lnAGE	**-60.2**	**0.043**	-26.86	0.279	-85.1	0.105
EDU	**7.44**	**0.030**	**9.43**	**0.000**	**18.8**	**0.034**
TRIPNUM	1.13	0.896	**2.37**	**0.000**	2.62	0.594
TRIPsq	-0.643	0.385	**-0.04**	**0.000**	-0.0708	0.610
FOREIGN	-19.1	0.326	**-29.59**	**0.004**	**-134.3**	**0.012**
MAINREAS	**91.8**	**0.001**	10.30	0.336	**119.5**	**0.003**
Heteroskedastic Function						
INCOME	-0.063	0.104	**0.05**	**0.000**	**0.177**	**0.000**
INCsq	0.002	0.191	**0.00**	**0.000**	**-0.005**	**0.000**
lnAGE	-0.479	0.069	**-0.61**	**0.000**	**-0.720**	**0.000**
EDUI	**0.099**	**0.000**	**0.11**	**0.000**	**0.073**	**0.005**
TRIPNUM	**0.343**	**0.017**	**0.11**	**0.000**	**0.144**	**0.001**
TRIPsq	**-0.140**	**0.001**	**0.00**	**0.000**	**-0.009**	**0.000**
FOREIGN	**-0.892**	**0.002**	**-1.36**	**0.000**	-2.01	0.092
MAINREAS	**1.148**	**0.000**	0.00	0.934	**0.733**	**0.000**
σ	199.6	0.393	**129.52**	**0.000**	347.71	0.180

The regression coefficients for the three sites vary extensively, casting doubt on the possibility that BFT may be judged as valid for either the temporal or the spatial/temporal combined transfer. Again using Kirchhoff's confidence interval criteria and the Wald test for equality of all coefficients, temporal and spatial/temporal combined transfers are tested, with results presented in table 5.10.

Table 5.10 Test Results for Temporal and Combined BFT

Temporal BFT (1992 San Pedro Study Site & 2001 San Pedro Policy Site)		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}]$ = \$133.39	$CI_{95\%Policy}$ = \$80.10⇔\$102.35	Ambiguous
$E[WTP_{Policy}]$ = \$91.22	$CI_{95\%BFT}$ = \$68.08⇔\$198.71	
Wald Test (Critical value = 28.87)		
W = 34,874		Reject BFT
Combined BFT (1992 San Pedro Study Site & KRP Policy Site)		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}]$ = \$124.19	$CI_{95\%Policy}$ = \$159.55⇔\$226.23	Reject BFT
$E[WTP_{Policy}]$ = \$192.89	$CI_{95\%BFT}$ = \$78.00⇔\$170.38	
Wald Test (Critical value = 28.87)		
W = 385,337		Reject BFT

The Kirchhoff criteria fails to produce definite results for the temporal BFT and rejects the combined BFT. The Wald test soundly rejects both types. As noted by Downing and Ozuna (1996), statistically similar WTP functions can yield statistically different expected WTP estimates. In the case of the temporal transfer, I believe that the converse of Downing and Ozuna's statement is being demonstrated. That is, that two statistically different WTP functions are producing similar WTP estimates. This may be due to random chance. But it could also be due to multicollinearity in the variables.

5.4.3 Multicollinearity & BFT

Gujarati (1995) notes that in the presence of high multicollinearity, regression coefficients can be sensitive to small changes in the data. Evidence of this is provided by Beaton (1976). This author slightly modified a set of collinear data by simulating rounding errors. These slight changes significantly changed parameter estimates (Kennedy 1998). This implies that if two or more of the independent variables specified by Kirchhoff are partially collinear[36] there may be significant differences in the estimated coefficients, even though the combined effects of the collinear independent variable on WTP may have been equal.

The existence of multicollinearity was investigated using auxiliary regressions upon the independent variables in each of the data sets. Not surprisingly the independent variable pairs Income & Income Squared, and Trip Number & Trip Number Squared, that were used in the temporal and combined BFTs displayed high degrees of multicollinearity in all three data sets.

One possible hypothesis is that due to the negative consequence of multicollinearity, a simplified model that contains few independent variables my fair better than a model that includes many independent variables, some of which may display high degrees of co-linearity. Of course an overtly simplified model may suffer from omitted variable bias, which can cause biased estimates of parameters, and larger errors (Kennedy 1998). However, in the context of BFT, these consequences may the lesser of two evils.

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[36] Collinearity may be the expectation with such variables as Income & Education, and perhaps Number of Trips & Main Reason for Trip.

To investigate the performance of a simplified WTP function, the spatial, temporal, and combined BFTs were performed again using the following specification.

$$WTP = \beta + \beta Income + \beta Education + \beta Trips + e$$

Notice that this specification uses only three independent variables, and assumes homoskedastic errors. Table 5.11 presents the regression results for each site using this simplified specification.

Table 5.11 Regression Results for Simplified WTP Function

	1992 San Pedro		2001 San Pedro		KRP	
	Coeff.	P-Val	Coeff	P-Val	Coeff	P-Val
Regression Function						
Constant	**-262.9**	**0.0261**	**-114.11**	**0.0138**	**-733.61**	**0.02375**
Income	3.42	0.3108	0.55	0.4169	10.46	0.12843
Education	**19.22**	**0.0067**	**9.86**	**0.0002**	**42.49**	**0.02040**
Number of Previous Trips	4.53	0.6551	1.67	0.1446	**30.18**	**0.00936**
σ	**213.3**	**0.0000**	**151.06**	**0.0000**	**446.85**	**0.00000**

Once again the variables differ drastically across sites, casting doubt upon the possibility that BFT will be deemed valid. Using the Kirchhoff method, and a Wald test for equality of the Beta coefficients (this Wald test did not test for equality of standard error estimates) all the various BFTs were tested, with results displayed in Table 5.12.

Table 5.12 BFT Test Results for Simplified Model

Spatial: KRP Study Site & 2001 San Pedro Policy Site		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}] = \$275.86$	$CI_{95\%Policy} = \$92.30 \Leftrightarrow \$109.87$	Reject BFT
$E[WTP_{Policy}] = \$101.08$	$CI_{95\%BFT} = \$223.57 \Leftrightarrow \$328.15$	
Wald Test (Critical value = 9.48)		
W = 1,328.81		Reject BFT
Spatial: 2001 San Pedro Study Site & KRP Policy Site		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}] = \$101.79$	$CI_{95\%Policy} = \$224.46 \Leftrightarrow \$322.23$	Reject BFT
$E[WTP_{Policy}] = \$273.34$	$CI_{95\%BFT} = \$92.78 \Leftrightarrow \$110.79$	
Wald Test (Critical value = 9.48)		
W = 19.33		Reject BFT
Temporal: 1992 San Pedro Study Site & 2001 San Pedro Policy Site		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}] = \$157.19$	$CI_{95\%Policy} = \$92.30 \Leftrightarrow \$109.87$	Reject BFT
$E[WTP_{Policy}] = \$101.08$	$CI_{95\%BFT} = \$124.79 \Leftrightarrow \$189.59$	
Wald Test (Critical value = 9.48)		
W = 106.04		Reject BFT
Temporal: 2001 San Pedro Study Site & 1992San Pedro Policy Site		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}] = \$92.39$	$CI_{95\%Policy} = \$110.99 \Leftrightarrow \$156.24$	Reject BFT
$E[WTP_{Policy}] = \$133.61$	$CI_{95\%BFT} = \$82.96 \Leftrightarrow \$101.83$	
Wald Test (Critical value = 9.48)		
W = 6.133		Fail to Reject BFT
Combined: 1992 San Pedro Study Site & KRP Policy Site		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}] = \$155.86$	$CI_{95\%Policy} = \$224.46 \Leftrightarrow \$322.24$	Reject BFT
$E[WTP_{Policy}] = \$273.35$	$CI_{95\%BFT} = \$124.40 \Leftrightarrow \$187.34$	
Wald Test (Critical value = 9.48)		
W = 9.64		Reject BFT
Combined: KRP Study Site & 1992 San Pedro Policy Site		
Kirchhoff Criteria		Test Result
$E[WTP_{BFT}] = \$213.27$	$CI_{95\%Policy} = \$110.99 \Leftrightarrow \$156.24$	Reject BFT
$E[WTP_{Policy}] = \$133.61$	$CI_{95\%BFT} = \$160.41 \Leftrightarrow \$266.12$	
Wald Test (Critical value = 9.48)		
W = 24.95		Reject BFT

Again BFT is overwhelmingly judged to be invalid. In 11 of the 12 tests, the null hypothesis was rejected. The one instance where BFT was not rejected was the Wald test of temporal transfer, using the 1992 San Pedro as the policy site. I posit that this result is due to the relatively large values in the variance covariance matrix for the 1992 San Pedro model, which were used in the calculation of the Wald test statistic, and not due to true validity of the transfer. This assertion is supported by the rejection of the other temporal transfer, which was testing the same coefficients but using the smaller variance covariance matrix from the simplified 2001 San Pedro model.

Unfortunately this investigation of the effects of multicollinearity on BFT fails to indicate that a simplified WTP model can improve benefit function transfer.

5.5 CVM Benefit Transfer Conclusion

While other studies have also rejected the validity of benefit transfer, most have not done so in such an overwhelming fashion. While it is likely that benefit transfer is an inaccurate way to estimate the non-market value of an environmental amenity, I posit that the results in this chapter also reflect the imperfect conditions in which this analysis was conducted. Specifically, the KRP survey used an annual payment format, while the San Pedro surveys elicited a one time contribution. This incongruity necessitated the adjustment of WTP values from the KRP studies, and surely hampered the effectiveness of transfers involving this site. Unfortunately, there was no way to rigorously calculate the needed adjustment. Therefore, the adjustments to the WTP values from the KRP study, are based on the best judgment of the researcher, and had an undeterminable effect on the results of the spatial and combined BFTs.

The temporal benefit transfers between the two San Pedro studies were conducted under almost ideal conditions, the only imperfections being slight differences in the survey instruments. Therefore, the results of these transfers can be viewed with a more critical eye. The temporal benefit value transfer was not rejected under two alternate tests. However, temporal benefit function transfer was rejected four times, accepted only once, and once provided ambiguous results. The inaccuracies of the WTP functions are to blame for the rejection of temporal BFT. Pseudo R-squared measures for all three CVM studies were extremely low, and many of the estimated coefficients were not significant at the 5% level[37]. If the models for WTP were completely and accurately explaining the variation bid amounts, then BFT should be valid. But if WTP functions are inaccurately explaining only a small percentage of bid variation, how can they be expected to be stable across studies? On the other hand, even though we cannot accurately explain variation in WTP, the results of the temporal BVT tests indicate that the distributions of the WTP bids were very similar in 1992 and 2001. This is a useful result, because in most circumstances it is the WTP values, not the functions at are of greatest interest to policy makes. However, failing to reject one set of temporal benefit value transfers does not unequivocally substantiate the validity of temporal BVT.

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[37] Note that low R-squared values and insignificant coefficients are the norm for WTP functions estimated from CVM data. This is because variation in WTP bids across individuals is largely due to immeasurable personal opinions regarding environmental issues, and individual attitudes about the CVM survey,

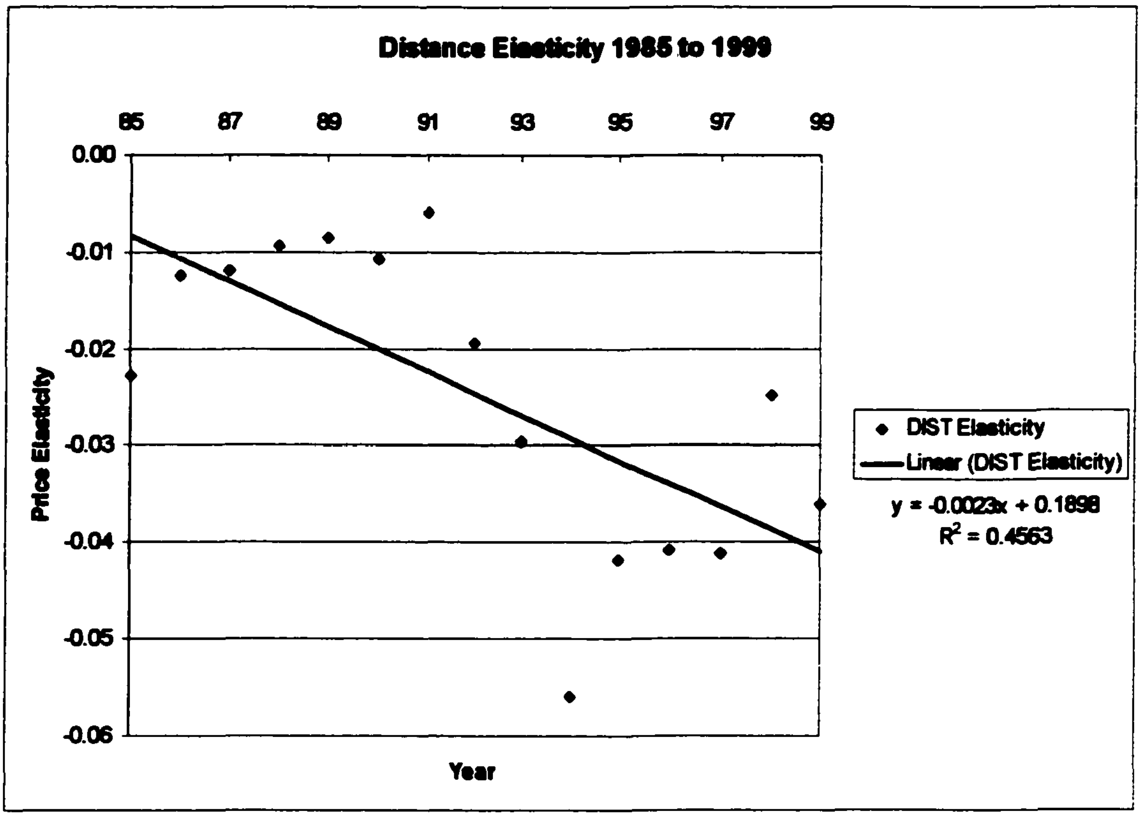
5.6 Extended Analysis of Temporal BVT

This section uses the Tanque Verde data set to extend the examination of temporal BVT. First, the estimated changes in the value of the Tanque Verde over time are reported. This is followed by the calculation of "success rates" for temporal BVT for time spans ranging from 1 to 14 years.

5.6.1 The Value of the Tanque Verde Over Time

General economic theory posits that, as the availability of substitutes decreases, the market value of a commodity should increase, ceterus paribus. This property is expected hold for non-market environmental amenities as well. When considering the value of the Tanque Verde riparian corridor it's reasonable to assume that over time the number of substitute amenities has been diminished by urban growth in the Tucson area. Therefore, the expectation is that the value of the Tanque Verde should be increasing. To test temporal BVT, individual regressions for each year were run using the double log specification. Complete regression results for each year are presented in appendix C. Coefficients were all of the expected sign, most were significant at the 5%, and R^2 values ranged from .74 to .84. The sales price of homes was adjusted to 2001 dollars to facilitate comparison to the San Pedro CVM studies. The graph below shows the estimated price elasticities associated with the Tanque Verde from 1985 to 1999, and a simple linear trend line.

Graph 5.13, Distance Elasticity 1985 to 1999



Note that a larger, negative elasticity value for distance from the Tanque Verde implies a larger positive value for proximity to the riparian corridor. The linear trend line is a poor fit for the erratic distance elasticity. There appears to be two distinct periods for the marginal implicit price of the Tanque Verde. The first period is from 85 to 92, when the value was low. Then from 93 to 99 the elasticity for Distance suddenly jumped. Using the partial derivatives of the estimated hedonic price functions[38], evaluated at the 1999 sample means, it's calculated that the marginal implicit price of the Tanque Verde increased from $3,573 in 1985, to $6,375 in 1999. This increase of 78% is almost six

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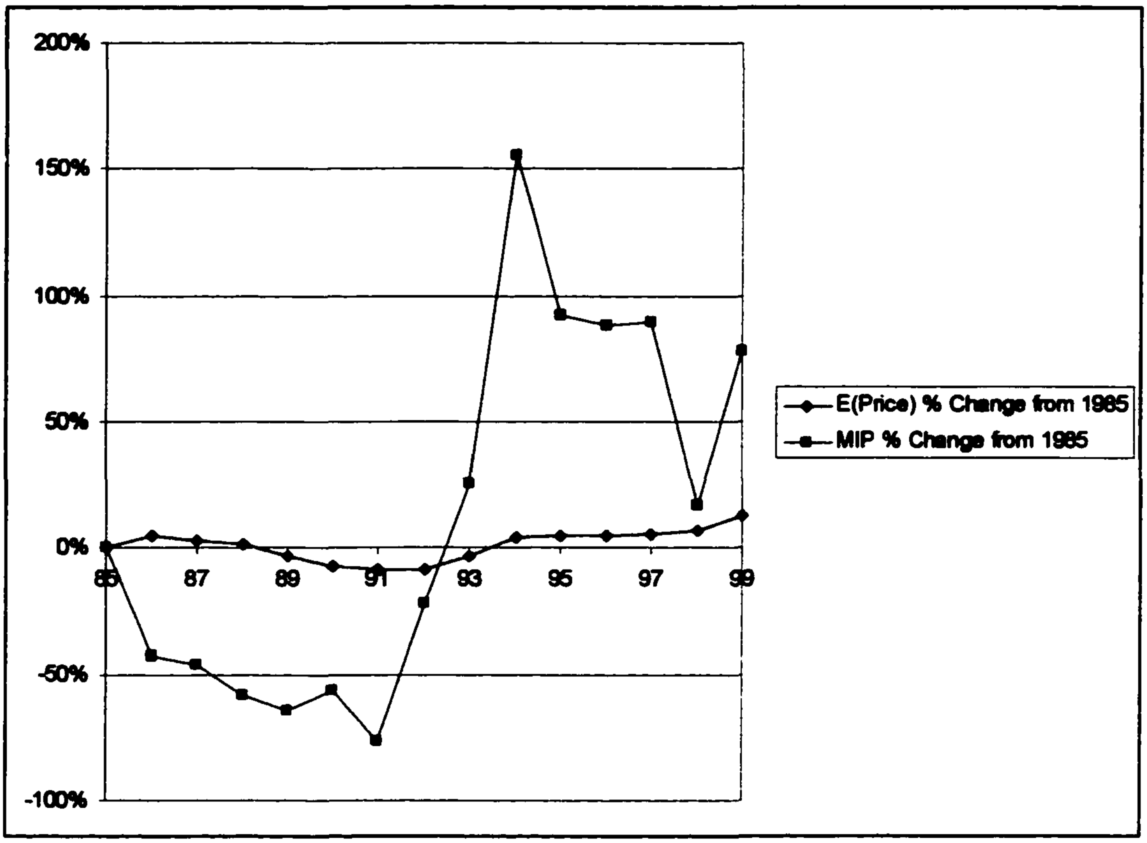
[38] $$\frac{\partial E(SALE\_AMT)}{\partial DIST} = E(SALE\_AMT)\beta_{\ln DIST}\frac{1}{DIST}$$

times larger than the 13% increase in average (inflation adjusted) home price over the same time period (as calculated from the data set).

The next graph shows the percentage change for the marginal implicit price (MIP) of the Tanque Verde, and the expected value of homes using the 99 sample means.

Graph 5.14, Percentage Change in MIP



At the beginning of this section, it was suggested that the MIP of the Tanque Verde should be responding to changes in the availability of substitute environmental sites. However, is it unlikely that the erratic changes in MIP could be accounted for by substitution effects alone. It's likely that the implicit values of the Tanque Verde measured by the hedonic models are primarily caused by unaccounted for changes in the housing market, and immeasurable changes in consumer preferences.

Regardless of the causes, the regression results indicate that value of the Tanque Verde jumped in the mid to late 90s. This implies that, if an economist or policy maker were attempting to weigh the costs and benefits of riparian conservation, using the results from a hedonic study that was over six or seven years old, the conclusions drawn could be seriously flawed.

5.6.2 BVT Using the Tanque Verde Study

In section 5.2, temporal BVT as not rejected, using the data from the two San Pedro CVMs. This section, extends the investigation of temporal BVT with the use of the results from the estimation of hedonic price function for the Tanque Verde Wash for the years 1985 to 1999.

The results from the Tanque Verde hedonic study are analyzed in a temporal BVT frame work, with the purpose of identifying the reliability of BVT for various time spans. While, due to the low cost associated with performing primary a hedonic analysis, temporal benefit transfer methods would rarely be needed for hedonic property price analysis. A better understanding of the stability of non-market values for environmental amenities over time is critical for efficient management of natural resources. Therefore this analysis provides a glimpse as to how reliable dated hedonic estimates may be.

Temporal BVT, in the context of this hedonic study, will be based on $\beta_{lnDistance}$. The hypothesis tested is whether or not this coefficient is equal across various time spans.

Even though the equality of coefficients is being tested, this is a test of benefit value transfer because $\beta_{lnDistance}$ is the sole basis for calculating value estimates of the Tanque Verde. The transferability of the entire hedonic function is not of interest to this study.

The temporal BVT Null Hypothesis:

$$H_o: \beta_{lnDist\ Year\ X} = \beta_{lnDist\ Year\ Y}$$

Is tested using Kirchhoff's method of confidence intervals and a Wald test for equality of coefficients. Note that because the Wald test is only testing a single coefficient, it reduces to what I termed a "Uni-directional Kirchhoff Test", which is simply a test for whether or not the coefficient from the study site falls with in the 95% confidence interval for the policy site coefficient. For the Krichhoff test there were 105 possible BVT test; one for a span of 14 years, two for a span of 13, and so on to 14 tests for a span of one year. Using the Wald test there were 210 possible tests for temporal transfer. The number of tests using the Wald is twice as high because it produces different results for a set of two years depending on which site is defined as the study site, and which is the policy site. Kirchhoff's method utilizes just one set of confidence intervals for a given pair of years, and therefore produces just one test result regardless of which site is defined as the policy. Table 5.15 presents the percentage of 'fail to reject' test results for the two tests, with temporal spans of 1 to 14 years.

Table 5.15 Percentage of hypothesis test that were not rejected

Time Span (Years)	Kirchhoff Criteria	Wald Test
1	64%	71%
2	62%	62%
3	50%	58%
4	45%	45%
5	40%	40%
6	33%	39%
7	13%	13%
8	14%	21%
9	0%	8%
10	0%	10%
11	0%	25%
12	0%	33%
13	50%	50%
14	0%	50%

The results in Table 5.13 are roughly inline with expectations, until the temporal span reaches 10 years. For the spans from one to nine years, the success rate of the benefit value transfer gradually drops as the number of years between the policy and study dates increases. Then the success rates jumps back up for spans of ten to fourteen years. This counter intuitive result is most likely explained by two factors. First, for larger time spans, there were fewer possible transfers to test. This caused one or two successful transfers to skew the results. Second, the coefficient estimates from 1985 and 1998 were unusually low and high respectively, in comparison to coefficients from nearby years. The anomalous estimates from 85 and 98 resulted in successful transfers over large time spans. This, combined with the low number of large time span transfers, satisfactorily explains the jump in the success rate.

5.6.3 Tanque Verde Temporal BVT Conclusions

The temporal BVT for the San Pedro studies was over a span of nine years and was not rejected. By contrast a nine year time span had the lowest success rate in the Tanque Verde analysis. The most probable explanation for this is that CVM estimates are more stable over time. I posit that this is because marginal implicit prices from hedonic studies react to the many changes in the real estate market, while contingent valuation estimates are based on hypothetical behavior which is likely to be less sensitive to actual conditions.

6. Conclusion

This thesis adds to the literature on non-market valuation of environmental amenities, and to the understanding of benefit transfer. Chapters Three, Four and Five presented different non-market valuation techniques. Chapter Three presented the analysis of contingent valuation data. The WTP equation demonstrated the construct validity of the Kern River CVM. The kernel density produced more rigorous estimation of the distribution of WTP bids, than does the commonly presented histogram. The hedonic property price valuation of the Tanque Verde riparian corridor in Chapter Four produced strong evidence of this amenity's positive value to home buyers. The double log specification was a good fit for the data, and resulted in a precise coefficient estimate for the variable Distance. This coefficient implied that for an average home, the expected sale price was almost $1,700 higher for a house located 1000 feet closer to the Tanque Verde (using a baseline distance of one mile). The two alternate aggregation methods resulted in total value estimates of $74,000,000 and $102,000,000. Chapter Five presented tests for the reliability of benefit transfer across locations and across time. The only other study to investigate transfers across time was Downing and Ozuna (1996), however the temporal transfers investigated by these authors spanned only three years (1987 to 1989). This thesis significantly improves on Downing and Ozuna's work by including many more transfers over a large range of time spans. Using two tests for BVT and two tests for BFT, the validity all most all the transfers were rejected, with the exception being temporal BVT. The analysis of temporal BVT was extended using the

Tanque Verde data set, and indicated that success rate of temporal BVT dropped form 71% to 8% as the temporal span increased from one year to nine.

6.1 Future Research

For benefit aggregation purposes, Chapter Four included a second stage estimation of a marginal willingness to pay (demand) function. As noted in that chapter, the method used was fraught with problems of identification in the second stage estimation. I suggest that following the example of Mahan, Polasky, and Adams (2000), an improved demand equation could be estimated for proximity to the Tanque Verde Wash using census tract data. Mahan, Polasky, and Adams' (2000) attempt at the same estimation, produced results that indicated an upward sloping demand curve. This disappointing result was most likely caused by insufficient data. The dataset used by those authors was inferior in depth and breadth to the Tanque Verde data set. It is possible that the same technique may produce better results when applied to the Tanque Verde dataset.

Also in Chapter Four the ample data set that was produced using Pima County's Geographical Information System (GIS) facilitated easy and accurate hedonic price function estimation. With a level of expertise using the required software, I propose that a natural resource economist could estimate the value of virtually all the open spaces in and around the Tucson area. A researcher could go so far as to develop a map of non-market values around the city. Such information could be useful in the development of land use plans, such as the Sonoran Desert Conservation Plan.

Another prospective avenue of research is to include variables that describe environmental quality in the estimation of a hedonic price function. In Chapter 4 distance to the Tanque Verde River was the only environmental variable included. A more accurate hedonic price function might include the quality of the riparian corridor at its closest point to the home site as an additional environmental variable. Collection of this data would require an ecological expert to evaluate the environmental heath of the wash all along its course, and to record his/her findings, using global positioning, or similar software. Being able to estimate the marginal effects of environmental quality would better facilitate the estimation of the benefits or costs of a proposed environmental policy that would affect the ecological health of a riparian corridor.

Chapter Five concluded with the estimation of hedonic price functions for each of the fourteen years included in the Tanque Verde data set. The results indicated a dramatic shift in the value of this riparian corridor, between the years 1991 and 1994. Investigation of what happened over this period might prove to be another interesting research topic. Was this a city wide phenomenon, or was it specific to the Tanque Verde? Are there any economic explanations for the apparent shift in consumer preferences? I propose that this analysis might start with interviews with Tucson real estate experts. Then continue with research into similar observed phenomena. How and why environmental values change over time is an area of research that has not been extensively investigated, and may produce very interesting results.

The end of Chapter Three presented the kernel density estimation of willingness to pay (WTP) bids for preservation of the Kern River Preserve. Another possible area of future research is to compare similar density estimates at different sites. Much has been written about the differences in mean WTP bids, and about differences between estimated WTP functions. However, differences in the skewness, kurtosis, and higher moments of WTP distributions have not been addressed to my knowledge. Research in this area should also include the estimation of densities using more advanced non-parametric techniques than those presented in Chapter Three.

Appendix A KRP Survey Instrument

1. Was this your first visit to the KR Valley? (Please refer to the area in the map on the cover page.)
   Yes ☐ No ☐

2. How much time did you spend in the KR Valley on this trip?
   ________ (Number of hours) *or*
   ________ (Number of days)

3. Was this your first visit to the Kern River Preserve?
   Yes ☐ No ☐

If not, how many trips have you made to the Kern River Preserve in the last two years?
________ (Number of trips)

4. How many people were in your party during your visit to the Kern River Preserve?
   ________ (Number of people)

5. On this trip, how much time did you spend at the Kern River Preserve?
   ________ (Number of hours)

6. Check which best describes the importance of the Kern River Preserve during this trip.

   ☐ Kern River Preserve is main trip destination.
   ☐ Kern River Preserve is one of several reasons for traveling to KR Valley.
   ☐ Kern River Preserve is a minor reason for traveling to KR Valley.
   ☐ Kern River Preserve is on route to main trip destination, located elsewhere.

7. What was the primary reason for your visit to the Kern River Preserve? (Please *check one*)

   ☐ To view wildlife
   ☐ General birding
   ☐ To look for a specific bird — (Please list species) ________________________
   ☐ Other, — (Please specify) ________________________

8. Please help us understand visitor spending patterns by estimating the total expenses for your trip to the KR Valley. We need to know how much money you have already spent and your estimated expenses for the rest of your trip. We also need to know how much of this spending occurs in the KR Valley. If you had no expenses in a particular category, please write in zero. If you were with a tour group, please report your fees paid directly to the tour company and also your out-of-pocket expenses while on the tour for each of the categories listed.

Are you reporting expenses for: ☐ Yourself, as an individual ☐ A group

If for a group, how many were in your group? _____ (Number of people)

	Total Estimated Trip Expenses	How much of this was spent in the KR Valley?
Gas for vehicle	_____	_____
Groceries	_____	_____
Restaurant and bar	_____	_____
Fees paid to tour company	_____	_____
Airfare	_____	_____
Car rental (*# of days rented:* _____)	_____	_____
Miscellaneous retail purchases (photography, clothing, books, maps, crafts, souvenirs, etc.)	_____	_____
Lodging:		
Bed and breakfast	_____	_____
Hotel/motel	_____	_____
RV park	_____	_____
Campground	_____	_____
Other (Please indicate type of lodging below)	_____	_____

____

9. On this trip to the KR Valley, how many nights will you stay in commercial accommodations: (Please indicate what *city* you stayed in and *how many nights*.)

Lake Isabella _____ Mountain Mesa _____ Weldon _____ Onyx _____ Kernville _____

Southlake _____ Bakersfield _____ Other towns/cities: _______________________

10. Where did you depart from when you set out for your trip to the KR Valley?

Within California:

☐ Los Angeles ☐ San Diego ☐ Bakersfield ☐ Fresno ☐ I live in KR Valley

☐ Other area in California: _______________________ ☐ Out of state: _______________________

The following questions are included to help us learn more about people's values for riparian areas. We are not soliciting contributions, and your responses are confidential.

11. The diverse birds and wildlife found on the Kern River Preserve require adequate water flows to support the healthy riparian habitat you experience on your visit to the Preserve. Suppose that these water flows are threatened and a non-profit foundation has been formed to acquire water and to promote regional water conservation in order to maintain the Preserve as it is now. If the foundation does not receive adequate contributions from individuals like yourself, adequate water flows will not be available. The trees along the river and in the flood plain would die, and gradually be replaced by grasses and small shrubs. The Preserve would no longer provide habitat for a wide variety and number of birds, butterflies, and other wildlife.

a. Please check the most, you as an individual, are willing to contribute to this non-profit foundation, in the form of ***a regular annual contribution***, in order to maintain the Kern River Preserve's riparian habitat as it is today:

☐ $00 ☐ $10 ☐ $20 ☐ $30 ☐ $50 ☐ $100 ☐ $200
☐ $300 ☐ $500 ☐ $750 ☐ $1000 ☐ *or other amount* : ______________

b. ***If your answer to question 11a was zero, or you left this space blank***, please check the ***one*** reason below that best explains why you answered this way:
- ☐ I would not benefit from preservation of riparian habitat at the Preserve.
- ☐ Preservation of this riparian habitat should be undertaken at no cost to me.
- ☐ I can go to other locations to enjoy riparian habitat and diverse bird and wildlife species.
- ☐ I need to spend money on other priorities.
- ☐ I 'd rather that others pay for the non-profit foundation's preservation activities.
- ☐ I did not fully understand what I was being asked to do.
- ☐ I found the question offensive or implausible.
- ☐ I'd rather make a one-time contribution of $ _______ (Please fill in)
- ☐ Other, please explain:

c. ***If your answer to 11a was greater than zero***, please answer the following question:
In order to actually make the contribution you checked for 11a, you would need to reduce spending on other items. Please indicate which ***one*** of the following categories you would spend less on:

☐ Groceries ☐ Entertainment ☐ Savings ☐ Contributions to environmental organizations
☐ Vacations ☐ Charitable contributions ☐ Other:

d. Now that you have thought about how you would rearrange spending to make the contribution that you answered for 11a, do you want to change the amount that you indicated? ☐ Yes ☐ No

If yes, please go back to 11a, cross out your first answer, and circle the revised amount.

e. *If your answer to question 11a was greater than zero*, please check the one reason that best explains why you are willing to contribute to the foundation.

- ☐ I am a regular visitor to the Preserve.
- ☐ I plan to become a regular visitor to the Preserve.
- ☐ I want the Preserve to be maintained so that others can enjoy it.
- ☐ I get satisfaction from knowing that the riparian habitat and the wildlife it supports will be maintained at the Preserve.
- ☐ The bird and wildlife species have a right to this riparian habitat.
- ☐ Other, please explain:

12. Suppose that water flows have not been preserved and the Preserve's trees have died out and have been replaced by grasses and small shrubs. The Preserve no longer provides habitat for a wide variety and number of birds, butterflies and other wildlife. Under these conditions, how often would you visit the Preserve over the course of a year?

☐ 0 visits ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 Other: ____ ☐ visits

13. How often do you plan to visit the Preserve, given its current healthy riparian habitat, over the next year?

☐ 0 visits ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 Other: ____ ☐ visits

Please complete these questions about yourself so we can analyze the responses we receive for a wide range of people. Your answers to these questions are confidential. You will not be identified in any analysis nor in any presentation of the study results.

14. Age: ___________ (Years)

15. Female ☐ Male ☐

16. Please indicate level of education:

☐ High School ☐ Some College/ Technical School ☐ Completed College/ Technical School ☐ Some Graduate/ Professional School ☐ Completed Graduate/ Professional School

17. Please indicate household income (before taxes) last year?

☐ Less than $10,000	☐ $30,000 - $34,999	☐ $60,000 - $69,999	☐ $150,000 - $199,999
☐ $10,000 - $14,999	☐ $35,000 - $39,999	☐ $70,000 - $79,999	☐ $200,000 - $249,999
☐ $15,000 - $19,999	☐ $40,000 - $44,999	☐ $80,000 - $89,999	☐ $250,000 - $499,999
☐ $20,000 - $24,999	☐ $45,000 - $49,999	☐ $90,000 - $99,999	☐ $500,000 - $749,999
☐ $25,000 - $29,999	☐ $50,000 - $59,999	☐ $100,000 - $149,999	☐ $750,000 - $1,000,000

18. Including yourself, how many individuals are in your household?

_________ (Adults) _________ (Children under 18)

19. What is your employment status?

☐ Employed full-time ☐ Employed part-time ☐ Unemployed ☐ Retired ☐ Student ☐ Homemaker

20. Are you a member of any organization which supports conservation, environmental or wildlife concerns?

Yes ☐ No ☐ If yes, please specify: ______________________________

21. Approximately how many <u>days per year</u> do you spend birding or hiking?

_________ Birding (Days per year)
_________ Hiking (Days per year)

22. Were there items or services you wished to purchase in the KR Valley area that were not available?

Yes ☐ No ☐ If yes, please specify: ______________________________

23. During this trip to the KR Valley, did you also: (Please check ***all*** those that apply)

☐ Raft on the Kern River ☐ Fish on the Kern River ☐ Fish on Lake Isabella
☐ Boat on the Kern River ☐ Boat on Lake Isabella ☐ Hike at other locations besides the Preserve

24. What do you think the main mission of the Kern River Preserve should be? (Please *check only one*)

☐ Protect and maintain riparian habitat.
☐ Promote environmental education in local schools.
☐ Promote environmental education with the KR Valley.
☐ Protect endangered wildlife and bird species.
☐ Provide high quality birding opportunities.
☐ Other (Please fill in): ______________________________

25. Please write any comments you wish to make about your experience at the Kern River Preserve, or any comments about this survey, here.

Thank you very much! Your time is greatly appreciated.

Appendix B Functional Form For the Hedonic Price Function

The choice of a functional form for the hedonic price function was reached after investigating numerous combinations of variables and variable transformations. This appendix compares the results from the final double log specifications to the results from 3 other common specifications; linear, linear-log, and log-linear. In section B.2 the hedonic price function is modeled using Box-Cox transformation of the variables. Section B.3 presents marginal effects for each specification, and B.4 presents the estimated aggregate values for each functional form.

The four most common specifications for hedonic models are as follows.

Double-Log

$$\ln Sale\_AMT = B \times \begin{bmatrix} Dummy96-99 \\ \ln Area \\ \ln Tot\_Live \\ Age \\ \ln Bath\_Fix \\ Garage \\ \ln Distance \end{bmatrix}$$

Linear

$$Sale\_AMT = B \times \begin{bmatrix} Dummy96-99 \\ Area \\ Tot\_Live \\ Age \\ Bath\_Fix \\ Garage \\ Distance \end{bmatrix}$$

Linear-Log

$$Sale\_AMT = B \times \begin{bmatrix} Dummy96-99 \\ \ln Area \\ \ln Tot\_Live \\ Age \\ \ln Bath\_Fix \\ Garage \\ \ln Distance \end{bmatrix}$$

Log-Linear

$$\ln Sale\_AMT = B \times \begin{bmatrix} Dummy96-99 \\ Area \\ Tot\_Live \\ Age \\ Bath\_Fix \\ Garage \\ Distance \end{bmatrix}$$

All of the alternative specifications were estimated using White's method to correct of heteroskedasticity of an unknown nature. The regression coefficients and t-stats for each model are presented in the chart below.

	Linear R Squared=.6656		**Linear-Log** R Squared=.5905		**Log-Linear** R Squared=.8059		**Double-Log** R Squared=.8366	
Variable Name	Estimated Coefficient	T-Stat	Estimated Coefficient	T-Stat	Estimated Coefficient	T-Stat	Estimated Coefficient	T-Stat
DUMMY96	-60212	-9.854	-1,366,210	-34.80	10.99	548.83	4.6254	56.26
DUMMY97	-57142	-9.102	-1,362,560	-34.62	11.00	552.45	4.6456	56.64
DUMMY98	-51516	-8.261	-1,355,440	-34.55	11.03	542.08	4.6829	56.86
DUMMY99	-33372	-5.194	-1,337,050	-34.17	11.11	521.83	4.7565	57.44
AREA	0.43822	6.166	35,453	19.54	0.00000135	3.32	0.16762	44.34
TOTLIVE	98.34	25.136	150,329	22.70	0.00045192	29.67	0.72724	48.47
AGE	-440.41	-5.122	-465	-4.61	-0.005135	-17.48	-0.005572	-20.80
BATH_FIX	3022	3.787	24,014	4.03	0.009173	4.01	0.10647	7.44
GARAGE	5718	4.977	9,810	7.70	0.034184	8.87	0.038520	11.54
DISTANCE	-6379	-5.228	-7,637	-7.70	-0.048618	-11.20	-0.044658	-18.37

Comparison of the coefficients across functional forms reveals little due to the transformation of variables. However, the double log specification provides the best overall fit and the most precise estimate of the coefficient of primary interest, DISTANCE. Note that because the dependent variable is transformed using the natural log operator, direct comparison should not be made across R^2 values. For direct comparison across functional forms each was modeled as a special case of the Box-Cox transformation. With this common form for each specification the likelihood values can be compared to evaluate which performs the best. The following table shows the Box-Cox coefficient specification that produces the desired model and the associated likelihood values.

	Box-Cox Coefficient Specification	Log-Likelihood
Linear	$\theta = 1, \lambda = 1$	-95,438
Linear-Log	$\theta = 0, \lambda = 1$	-96,214
Log-Linear	$\theta = 1, \lambda = 0$	1,491
Double Log	$\theta = 0, \lambda = 0$	2,150

To further establish the overall precision of the various models, the table below shows the 95% confidence intervals for the expected sale amount evaluated at the sample means.

95% Confidence Intervals

	Low	Mean*	High	Spread
Linear	$180,893	$ 182,295	$ 183,697	$2,804
Linear-Log	$180,744	$ 182,295	$ 183,846	$3,103
Log-Linear	$161,778	$ 162,502	$ 163,229	$1,451
Double-Log	$161,838	$ 162,502	$ 163,169	$1,331

*Mean predictions vary due to non-linear transformation of variables.

Each different specification implies a different relationship between the dependent and the independent variables. These relationships are expressed in the various interpretations of the regression coefficients. For the linear model the coefficients are, of course, the marginal implicit prices. For the linear-log model the coefficients for the transformed variables are interpreted as the absolute change in sale price for a percentage change in the independent variable.

$$\beta_i = \frac{\Delta Sale\_Amt}{\Delta X_i / X_i}$$

The coefficients for the log-linear model are interpreted as the percentage change in sale price for an absolute change in the independent variable.

$$\beta_i = \frac{\Delta Sale\_Amt / Sale\_Amt}{X_i}$$

Finally, as noted in section 3.2, the coefficients for the double-log specification are interpreted as elasticities, which are percentage change in the dependent variable for a percentage change in the independent variable.

$$\beta_i = \frac{\Delta Sale\_Amt / Sale\_Amt}{\Delta X_i / X_i}$$

B.2 Box Cox Specification

Another possible functional form for hedonic price functions is the Box-Cox model. Halvorsen and Pollakowski (1981) note that many of the commonly specified forms for hedonic price functions place unwarranted restrictions on the underlying supply and demand equations. They posit that a possible solution to this is to use a more flexible form, and a Box-Cox transformation of the variables. For the Tanque Verde data set the following Box-Cox model was specified:

$$\frac{\left(Sale\_Amt^{\theta} - 1\right)}{\theta} = \beta_{1-6} \begin{bmatrix} Dummy96 \\ Dummy97 \\ Dummy98 \\ Dummy99 \\ Age \\ Garage \end{bmatrix} + \beta_7 \left(\frac{\left(Area^{\lambda} - 1\right)}{\lambda} \right) + \beta_8 \left(\frac{\left(Tot\_Live^{\lambda} - 1\right)}{\lambda} \right) + \beta_9 \left(\frac{\left(\text{Distance}^{\lambda} - 1\right)}{\lambda} \right)$$

Note that independent variables that take a value zero cannot have the Box-Cox transformation applied to them. The estimated transformation parameters were:

$$\theta = -0.4540745186 \quad (0.011783288)$$
$$\lambda = 0.00099180179 \quad (0.019660754)$$

The lambda parameter is not significantly different from zero. This is interesting because a Box-Cox parameter of zero implies a natural log transformation, which was the transformation used in the main regression in Chapter 4. A Likelihood ratio test can be used to test the restriction that both Box-Cox parameters are equal to zero. If they were indeed zero, the result would be the double-log specification. The result of this likelihood ratio test overwhelmingly rejected the null hypothesis, indicating that the specification in Chapter 4 could be improved upon.

B.3 Marginal Effects and Implicit Prices

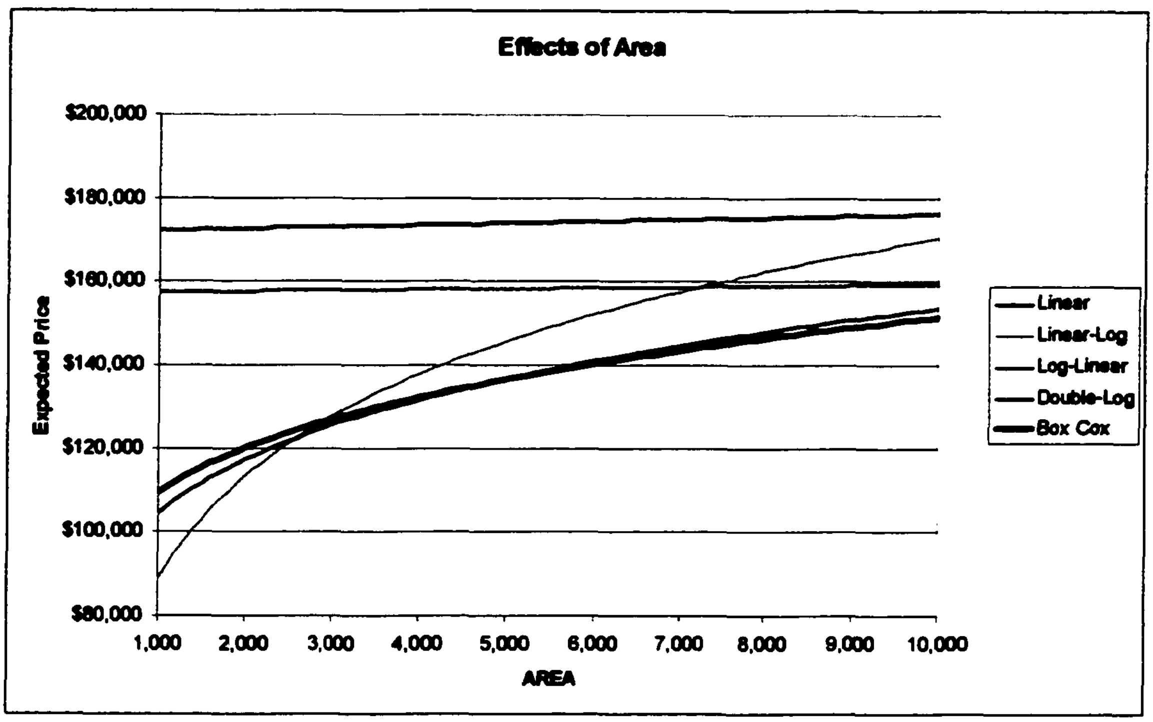
For a final comparison of the various functional forms presented in this appendix, this section presents the marginal implicit prices for distance to the Tanque Verde and for total living space for each functional form, and charts displaying the marginal effects for all variables.

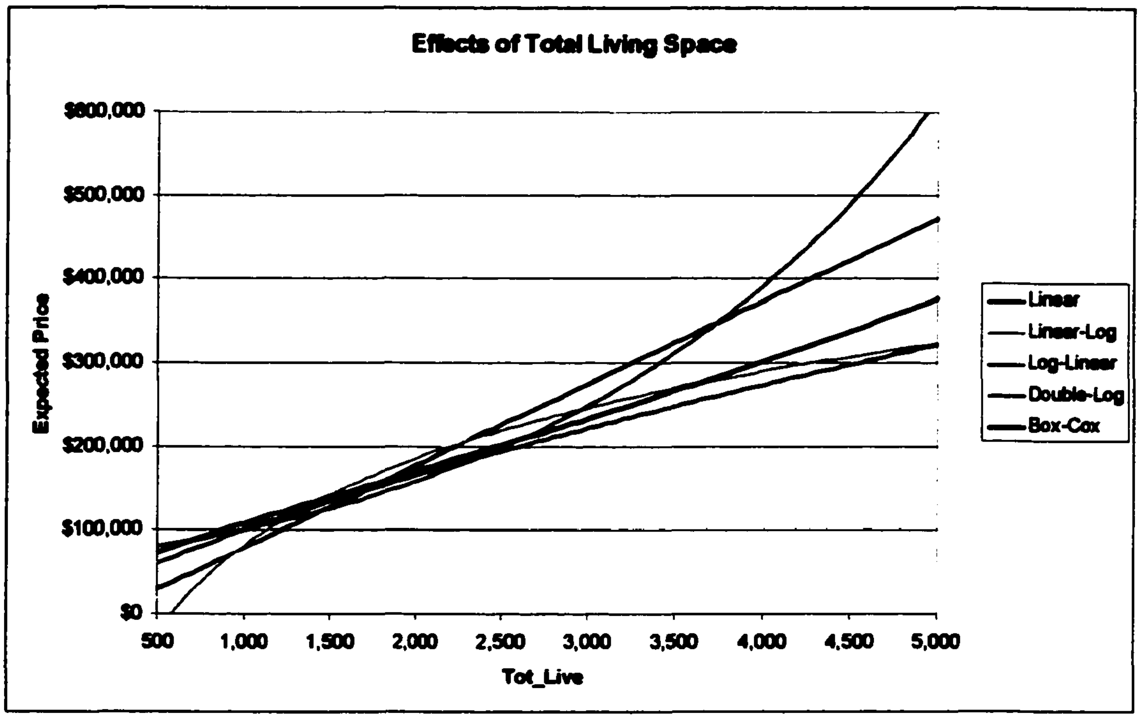
The primary interest of the hedonic study was to calculate the marginal implicit price of proximity to the Tanque Verde. As done in Chapter Four, this section will estimate the marginal implicit price in the same manor as Mahan, Polasky, and Adams (2000). This method estimates the increase in mean home value for a 1000 foot decrease in distance from the Tanque Verde riparian corridor, with a baseline distance of one mile.

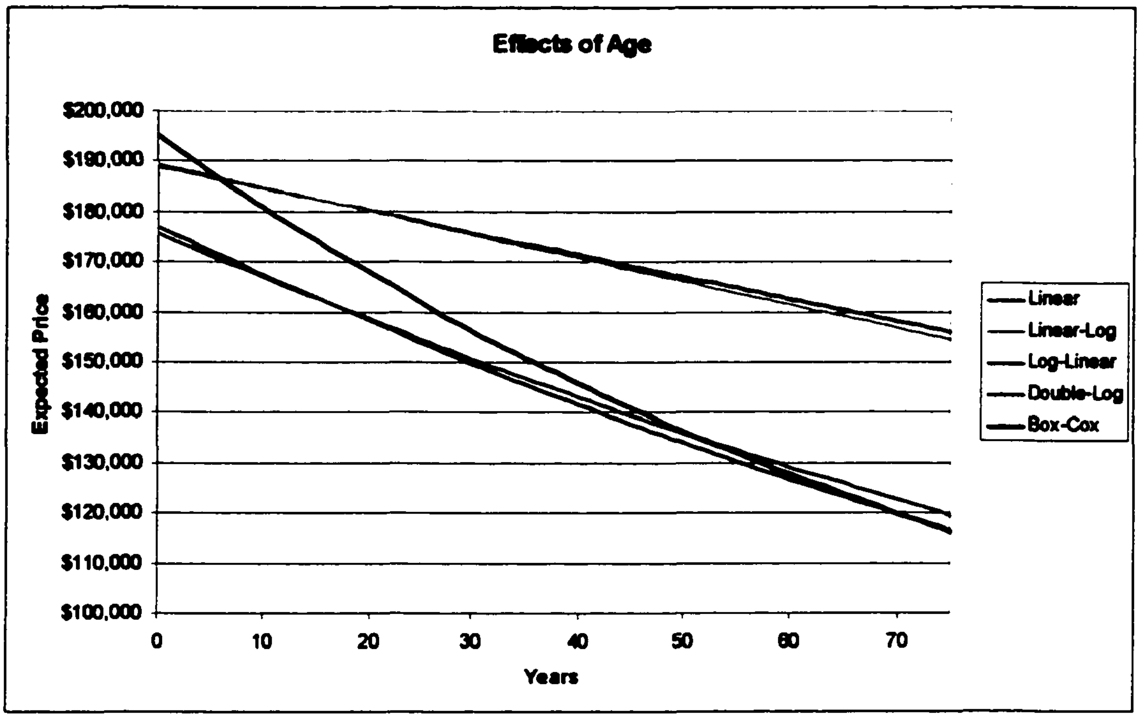
In addition the following table includes the marginal implicit price for a one square foot increase in total living space, with a base line of 2000 square feet.

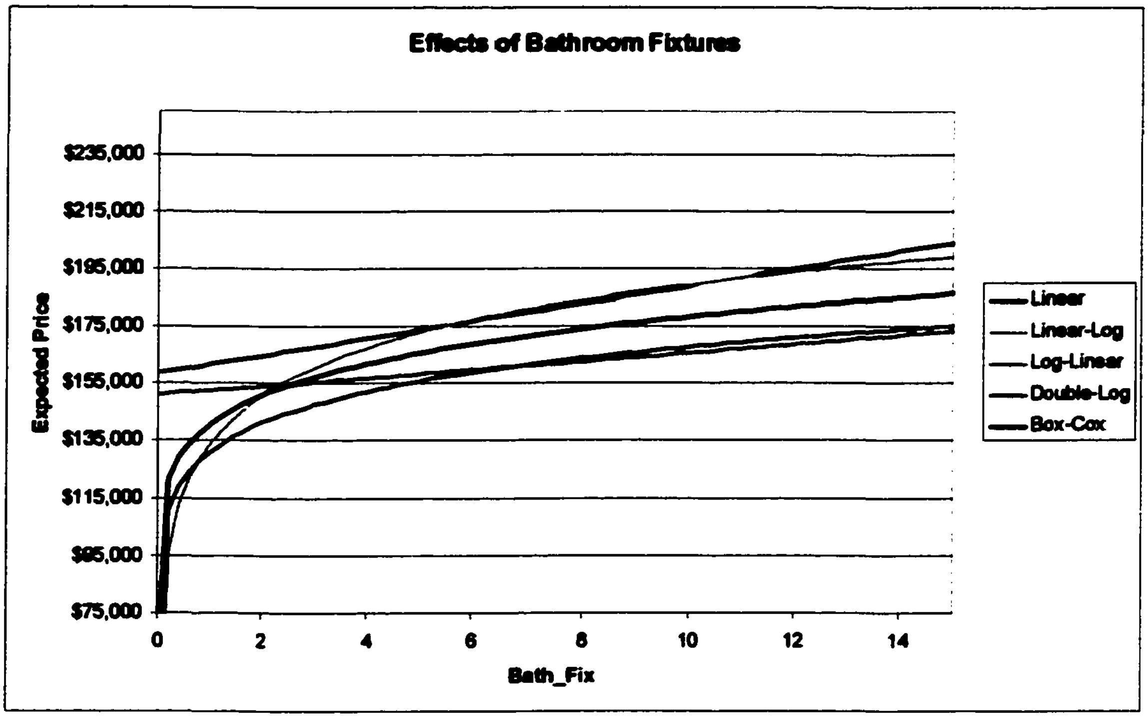
	Marginal Implicit Price for Total Living Space	Marginal Implicit Price for Proximity to the Tanque Verde
Linear	$ 98.34	$ 1,208
Linear-Log	$ 75.15	$ 1,325
Log-Linear	$ 71.72	$ 1,478
Double Log	$ 60.13	$ 1,228
Box-Cox	$ 61.88	$ 1,391

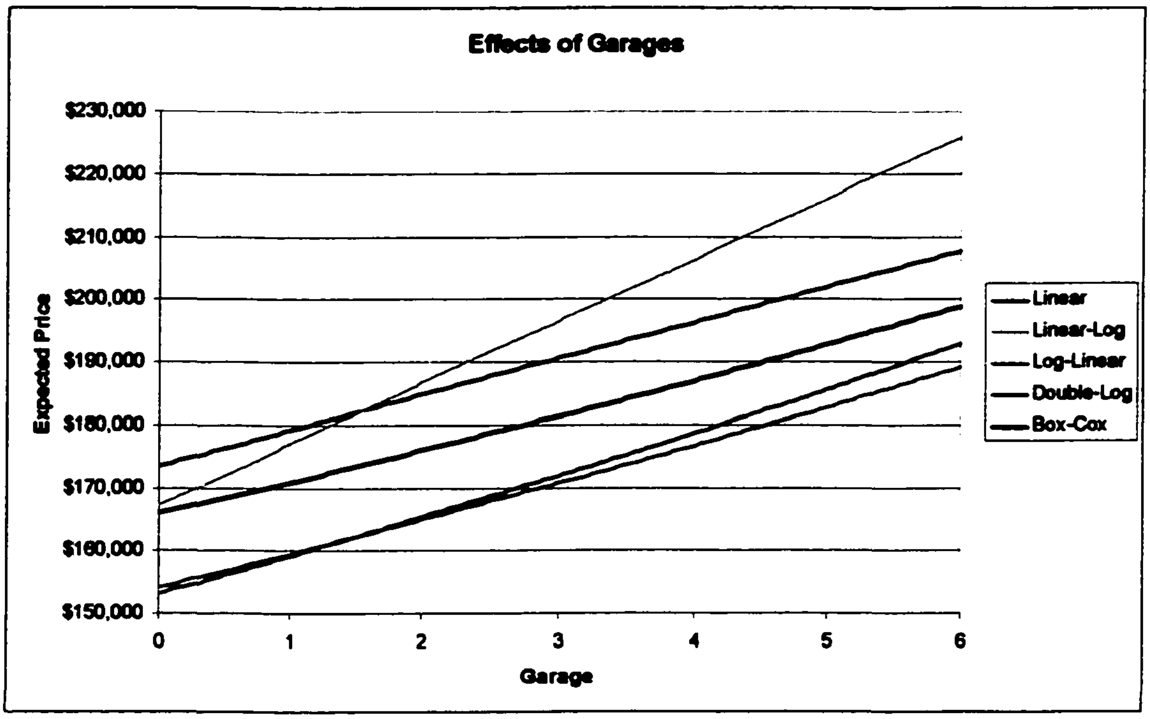
The following figures graph the effects of all the variables for all of the functional forms.

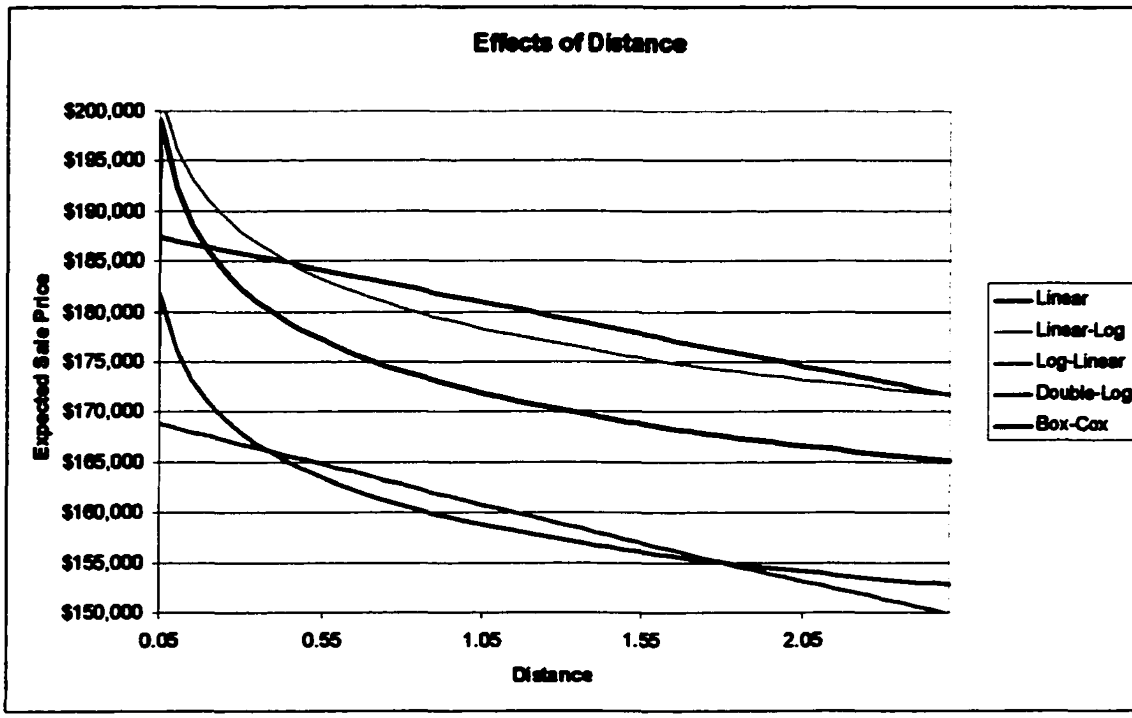



Effects of Total Living Space
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
Expected Price
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
Tot_Live
Linear
Linear-Log
Log-Linear
Double-Log
Box-Cox


Effects of Age
$200,000
$190,000
$180,000
$170,000
$160,000
$150,000
$140,000
$130,000
$120,000
$110,000
$100,000
Expected Price
0
10
20
30
40
50
60
70
Years
Linear
Linear-Log
Log-Linear
Double-Log
Box-Cox


Effects of Bathroom Fixtures
Expected Price
$235,000
$215,000
$195,000
$175,000
$155,000
$135,000
$115,000
$95,000
$75,000
0
2
4
6
8
10
12
14
Bath_Fix
Linear
Linear-Log
Log-Linear
Double-Log
Box-Cox


Effects of Garages
Expected Price
$230,000
$220,000
$210,000
$200,000
$190,000
$180,000
$170,000
$160,000
$150,000
0
1
2
3
4
5
6
Garage
Linear
Linear-Log
Log-Linear
Double-Log
Box-Cox

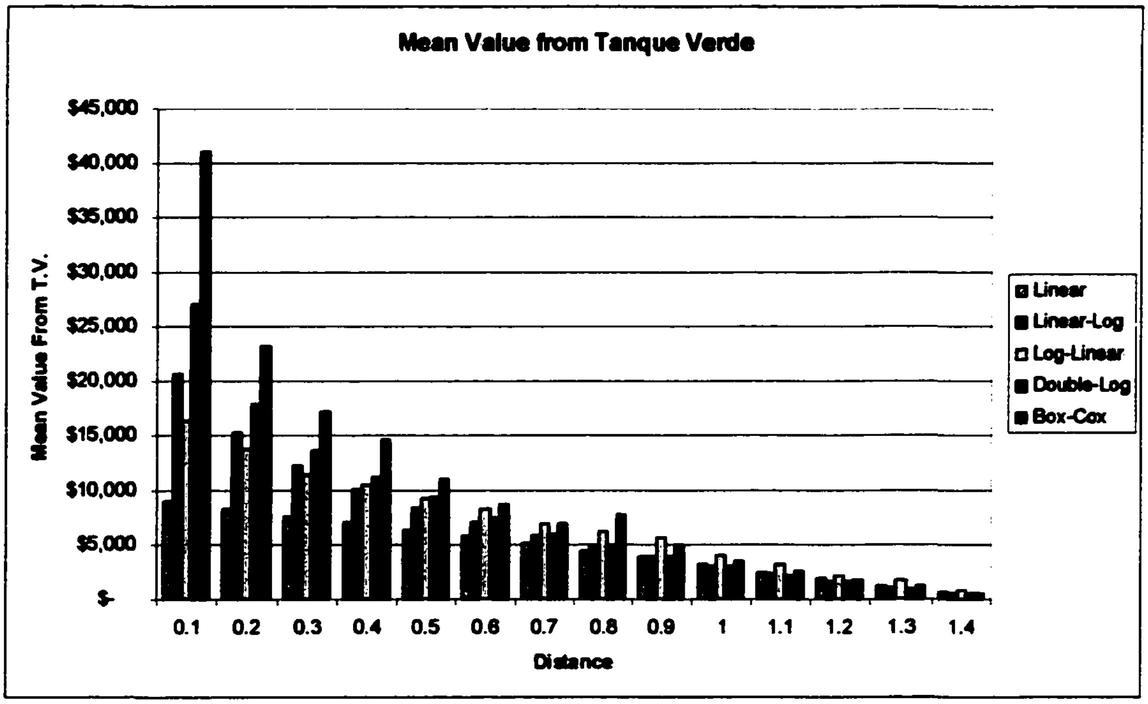


B.4 Value Aggregation

There are two aggregation techniques presented in Section 4.4. The first uses the hedonic price function only. The other uses an estimate of consumer marginal willingness to pay. This section presents aggregation estimates using the first method, for the linear, linear-log, log-linear, double-log and Box-Cox specifications. The second method is not used due to identification problems in the second stage regression.

	Aggregate Value of Tanque Verde Riparian Corridor
Linear	$139,583,675.79
Linear-Log	$206,092,000.78
Log-Linear	$214,552,517.53
Double-Log	$232,255,571.69
Box-Cox	$303,141,225.49

The table above shows that the more flexible specifications that allow for non-linear relationships between sale price and the explanatory variables produces higher aggregate values. The next table displays the aggregate value for each distance, for each hedonic price function specification.



This graph clearly shows how the most flexible specification, the Box-Cox, estimates very large benefits resulting from proximity to the Tanque Verde, for the homes closest to the riparian corridor. Also, as the distance increases all the various functional forms result in similar benefit estimates.

Appendix C Regression Results for Hedonic Price Functions 1985 to 1999

	Coefficient	Standard Error	T-Stat	P[|Z|>z]	Mean
1985					
Constant	5.943951852	.22895919	25.961	.0000	
LNAREA	.2574468090E-01	.11223379E-01	2.294	.0218	9.3364910
LNTOTLIV	.7303931043	.45918149E-01	15.906	.0000	7.4774990
AGE	-.9024149121E-02	.96540199E-03	-9.348	.0000	9.3495401
LNBATH	.1708217351	.46918300E-01	3.641	.0003	1.8937636
GARAGE	.5425750402E-01	.80230228E-02	6.763	.0000	1.0893561
LNDIST	-.2276344447E-01	.11685406E-01	-1.948	.0514	-.52873592
1986					
Constant	5.714401714	.21483379	26.599	.0000	
LNAREA	.3921785151E-01	.86904646E-02	4.513	.0000	9.3506195
LNTOTLIV	.7519552097	.38880160E-01	19.340	.0000	7.4643391
AGE	-.7979488268E-02	.85091450E-03	-9.378	.0000	11.044809
LNBATH	.1493783270	.37346616E-01	4.000	.0001	1.8866686
GARAGE	.6987067065E-01	.74494332E-02	9.379	.0000	1.0284153
LNDIST	-.1233775134E-01	.78381519E-02	-1.574	.1155	-.56912217
1987					
Constant	5.951428798	.20595548	28.897	.0000	
LNAREA	.6119684039E-01	.95046304E-02	6.439	.0000	9.3710138
LNTOTLIV	.6603911416	.40957393E-01	16.124	.0000	7.4774926
AGE	-.7164407990E-02	.80934943E-03	-8.852	.0000	10.288479
LNBATH	.2655639096	.41480477E-01	6.402	.0000	1.9200259
GARAGE	.5896872900E-01	.65407897E-02	9.016	.0000	1.1935484
LNDIST	-.1190732216E-01	.74709154E-02	-1.594	.1110	-.50802672
1988					
Constant	5.724938544	.20590900	27.803	.0000	
LNAREA	.6541379022E-01	.81285917E-02	8.047	.0000	9.3027564
LNTOTLIV	.7048111765	.38899969E-01	18.119	.0000	7.4847193
AGE	-.7612974781E-02	.82734642E-03	-9.202	.0000	11.431211
LNBATH	.1810380572	.37070353E-01	4.884	.0000	1.9318494
GARAGE	.6937129663E-01	.76203448E-02	9.103	.0000	1.1735113
LNDIST	-.9366798957E-02	.77053274E-02	-1.216	.2241	-.55018630
1989					
Constant	5.465877793	.22580128	24.207	.0000	
LNAREA	.7797449072E-01	.85802678E-02	9.088	.0000	9.4002123
LNTOTLIV	.7111858909	.38394302E-01	18.523	.0000	7.4974482
AGE	-.7452209083E-02	.10130396E-02	-7.356	.0000	12.752049
LNBATH	.2087660394	.51031925E-01	4.091	.0000	1.9099763
GARAGE	.6137908145E-01	.74020473E-02	8.292	.0000	1.1547131
LNDIST	-.8445089530E-02	.88468710E-02	-.955	.3398	-.54459161
1990					
Constant	5.360945751	.21430056	25.016	.0000	
LNAREA	.9203984509E-01	.11584435E-01	7.945	.0000	9.3333459
LNTOTLIV	.7077054201	.41773963E-01	16.941	.0000	7.4884229
AGE	-.8284828874E-02	.92539688E-03	-8.953	.0000	12.949900
LNBATH	.2023689154	.42776610E-01	4.731	.0000	1.9249149
GARAGE	.5277964693E-01	.77166611E-02	6.840	.0000	1.2274549
LNDIST	-.1069879881E-01	.10072374E-01	-1.062	.2881	-.59960034

1991					
Constant	5.330178118	.17230844	30.934	.0000	
LNAREA	.8036892672E-01	.87577083E-02	9.177	.0000	9.4101859
LNTOTLIV	.7211145079	.33236984E-01	21.696	.0000	7.5089641
AGE	-.7665046544E-02	.75575840E-03	-10.142	.0000	14.515929
LNBATH	.2046557574	.35739784E-01	5.726	.0000	1.9292536
GARAGE	.5787917005E-01	.71968114E-02	8.042	.0000	1.1132743
LNDIST	-.5869749740E-02	.74328978E-02	-.790	.4297	-.55050353
1992					
Constant	4.907280399	.15548338	31.561	.0000	
LNAREA	.1026927584	.76407322E-02	13.440	.0000	9.3088332
LNTOTLIV	.7639791665	.29931684E-01	25.524	.0000	7.4951710
AGE	-.6977828147E-02	.56455855E-03	-12.360	.0000	13.734063
LNBATH	.1464318234	.28274078E-01	5.179	.0000	1.9428110
GARAGE	.5124792411E-01	.57215092E-02	8.957	.0000	1.2324533
LNDIST	-.1943491349E-01	.61478627E-02	-3.161	.0016	-.62752354
1993					
Constant	5.058807168	.16009173	31.599	.0000	
LNAREA	.1156481662	.69299053E-02	16.688	.0000	9.3157528
LNTOTLIV	.7373466196	.29602677E-01	24.908	.0000	7.5066583
AGE	-.5806069775E-02	.61332722E-03	-9.467	.0000	14.287162
LNBATH	.1203307873	.27659364E-01	4.350	.0000	1.9469026
GARAGE	.5625345413E-01	.56523624E-02	9.952	.0000	1.2554054
LNDIST	-.2962487035E-01	.57911767E-02	-5.116	.0000	-.59581751
1994					
Constant	4.800727816	.15044994	31.909	.0000	
LNAREA	.1015931489	.72353064E-02	14.041	.0000	9.3100233
LNTOTLIV	.8072097815	.27487673E-01	29.366	.0000	7.5206267
AGE	-.6538111045E-02	.55371444E-03	-11.808	.0000	13.930827
LNBATH	.9093605170E-01	.24935882E-01	3.647	.0003	1.9655027
GARAGE	.5262554572E-01	.53864345E-02	9.770	.0000	1.3619048
LNDIST	-.5586410095E-01	.60810987E-02	-9.187	.0000	-.51620412
1995					
Constant	5.078306116	.16341587	31.076	.0000	
LNAREA	.1313039037	.75643797E-02	17.358	.0000	9.2917895
LNTOTLIV	.7261084147	.30814449E-01	23.564	.0000	7.5154639
AGE	-.5983417882E-02	.57844250E-03	-10.344	.0000	14.123744
LNBATH	.1289631520	.31313461E-01	4.118	.0000	1.9761416
GARAGE	.4254220861E-01	.55403063E-02	7.679	.0000	1.4029614
LNDIST	-.4176937004E-01	.51970993E-02	-8.037	.0000	-.55981583
1996					
Constant	5.191809052	.14118079	36.774	.0000	
LNAREA	.1272389726	.54490528E-02	23.351	.0000	9.2797167
LNTOTLIV	.7109542881	.25057995E-01	28.372	.0000	7.5137183
AGE	-.4878240320E-02	.49291812E-03	-9.897	.0000	14.781500
LNBATH	.1429227580	.25730998E-01	5.554	.0000	1.9682048
GARAGE	.4062290034E-01	.52858481E-02	7.685	.0000	1.4180000
LNDIST	-.4076715870E-01	.41965220E-02	-9.715	.0000	-.56772872

1997					
Constant	4.884134360	.13423053	36.386	.0000	
LNAREA	.1267448553	.62066437E-02	20.421	.0000	9.2793388
LNTOTLIV	.7557197178	.27353087E-01	27.628	.0000	7.5270923
AGE	-.5845064473E-02	.50791184E-03	-11.508	.0000	13.979601
LNBATH	.1396428841	.29921577E-01	4.667	.0000	2.0014208
GARAGE	.3929804874E-01	.51753678E-02	7.593	.0000	1.5405865
LNDIST	-.4106391395E-01	.43097176E-02	-9.528	.0000	-.52709997
1998					
Constant	4.669088760	.11924880	39.154	.0000	
LNAREA	.1277725022	.57678702E-02	22.152	.0000	9.2247146
LNTOTLIV	.7993944743	.22627990E-01	35.328	.0000	7.5248281
AGE	-.5421271748E-02	.42383669E-03	-12.791	.0000	14.598265
LNBATH	.8296920250E-01	.19951688E-01	4.159	.0000	1.9919198
GARAGE	.4490327886E-01	.49041313E-02	9.156	.0000	1.5051718
LNDIST	-.2487073801E-01	.40910914E-02	-6.079	.0000	-.54779601
1999					
Constant	4.716927037	.16365762	28.822	.0000	
LNAREA	.1635554801	.89220047E-02	18.332	.0000	9.2983633
LNTOTLIV	.7692510107	.31217530E-01	24.642	.0000	7.5355656
AGE	-.7530025356E-02	.52524757E-03	-14.336	.0000	17.048790
LNBATH	.4802398624E-01	.28228124E-01	1.701	.0889	1.9839640
GARAGE	.4396519002E-01	.62840569E-02	6.996	.0000	1.4427419
LNDIST	-.3595969671E-01	.59372509E-02	-6.057	.0000	-.57932603

Appendix D Results from Benefit Transfer Tests Using Unadjusted Values from KRP

The WTP values for the KRP CVM were adjusted in an attempt the reconcile the difference between the KRP's annual payment format and the San Pedro's one time contribution format. However, this adjustment was based solely on the intuition of the author. To investigate benefit transfer in the absence of any subjective interference from the author, this appendix presents the results of the same tests as those in Chapter 5 using unadjusted WTP values from the KRP. As a reminder the mean unadjusted WTP from the KRP was $76.37, the adjusted WTP from the 1992 San Pedro was $103.18[39],

Table D.1 Results of Wilcoxon Rank Sum Test

	Null Hypothesis	Wilcoxon Test Statistic	2-Tailed P-Value[40]	Test Result
1.	H_o: $\overline{WTP}_{KRP} = \overline{WTP}_{SP01}$	-1.386	0.167	Fail to Reject
2.	H_o: $\overline{WTP}_{SP92} = \overline{WTP}_{SP01}$	-0.055	0.96	Fail to Reject
3.	H_o: $\overline{WTP}_{SP92} = \overline{WTP}_{KRP}$	1.649	.099	Fail To Reject

Table D.2 Expected WTP & Confidence Intervals

CVM Study	E[WTP]	$CI_{95\%}$
San Pedro 1992	$107.73	$87.73 ⇔ $127.72
San Pedro 2001	$98.88	$85.28⇔ $112.49
KRP	$73.32	$63.80⇔ $82.84

Table D.3 Results of Kirchhoff's Confidence Interval Test

	Null Hypothesis	% Difference	Test Result
1.	H_o: $E[WTP_{KRP}]=E[WTP_{SP01}]$	34.9%	Reject
2.	H_o: $E[WTP_{SP92}]=E[WTP_{SP01}]$	-8.2%	Fail to Reject
3.	H_o: $E[WTP_{SP92}]=E[WTP_{KRP}]$	-31.9%	Reject

[39] The unadjusted value from the 1992 San Pedro was not investigated because the adjustment made was based on rigorous economic theory and data. Unlike the KRP adjustment which was largely subjective in nature.

[40] The 2-tailed p-value indicates the probability that the null hypothesis of equal mean WTP is true.

Table D.4 Test Results for Spatial BFT

KRP Study Site & 2001 San Pedro Policy Site

Kirchhoff Criteria		Test Result
$E[WTP_{BFT}]$ = \$71.02	$CI_{95\%Policy}$ = \$87.10⇔\$108.21	Reject BFT
$E[WTP_{Policy}]$ = \$97.66	$CI_{95\%BFT}$ = \$59.93⇔\$82.12	
Wald Test (Critical value = 16.92)		
W = 89.86		Reject BFT

2001 San Pedro Study Site & KRP Policy Site

Kirchhoff Criteria		Test Result
$E[WTP_{BFT}]$ = \$176.22	$CI_{95\%Policy}$ = \$62.30⇔\$90.11	Reject BFT
$E[WTP_{Policy}]$ = \$76.20	$CI_{95\%BFT}$ = \$141.38⇔\$211.07	
Wald Test (Critical value = 23.68)		
W = 17,962		Reject BFT

Table D.5 Test Results for Temporal and Combined BFT

Temporal BFT (1992 San Pedro Study Site & 2001 San Pedro Policy Site)

Kirchhoff Criteria		Test Result
$E[WTP_{BFT}]$ = \$133.39	$CI_{95\%Policy}$ = \$80.10⇔\$102.35	Ambiguous
$E[WTP_{Policy}]$ = \$91.22	$CI_{95\%BFT}$ = \$68.08⇔\$198.71	
Wald Test (Critical value = 28.87)		
W = 34,874		Reject BFT

Combined BFT (1992 San Pedro Study Site & KRP Policy Site)

Kirchhoff Criteria		Test Result
$E[WTP_{BFT}]$ = \$124.19	$CI_{95\%Policy}$ = \$56.38⇔\$79.77	Reject BFT
$E[WTP_{Policy}]$ = \$68.07	$CI_{95\%BFT}$ = \$78.00⇔\$170.38	
Wald Test (Critical value = 28.87)		
W = 17,217		Reject BFT

Using the unadjusted KRP data resulted in only two test results that are different from those in Chapter 5, both are from the Wilcoxon test of BVT. Using the adjusted KRP data, BVT between the KRP and the two San Pedro studies was rejected, using the unadjusted KRP data these transfers were not rejected. This result is not surprising because the mean unadjusted WTP from the KRP was much closer to the San Pedro means. Also it is interesting to note that BFT continues to be soundly rejected, proving further evidence that this is an unreliable technique.

Appendix E Benefit Transfer Econometrics

E.1 Wilcoxon or Mann-Whitney rank sum test.

The Wilcoxon rank sum test is suggested for use with BVT by Brouwer and Spaninks (1999). They note that, when used to calculate confidence intervals, the common t-stat requires the assumption that the amounts are drawn from a normal distribution. Given the truncated nature of CVM data this assumption would be violated. Therefore the authors specify the Wilcoxon rank sum test. This non-parametric test requires no assumption about the specific shape of the WTP distribution, only that the distributions from the two sites being tested be similar in shape but not location.

To calculate the Wilcoxon test statistic, observations of WTP from the two data sets are combined and ranked from smallest to largest. The statistic W is the sum of the ranks for the study site. For the normal approximation we can calculate the mean as

$$\mu = \frac{n_1(n_1 + n_2 + 1)}{2}$$

Here n_1 and n_2 are the number of observations from the study site and the policy respectively. The standard error is calculated as;

$$\sigma = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}$$

And the z score as

$$z = \frac{W - \mu}{\sigma}$$

The BVT null hypothesis were tested at the 95% confidence level. Therefore the null hypothesis of equal mean WTP is rejected if the absolute value of the Z score for the Wilcoxon is above 1.96. (http://filebox.vt.edu/artsci/stats/waterman/RankSum.htm)

E.2 E[WTP]

The expected willingness to pay using a heteroskedastic Tobit model is calculated as follows.

$$E[WTP] = \beta'\overline{X} \cdot \Phi\left(\frac{\beta'\overline{X}}{\sigma \cdot e^{\bar{g} \cdot \gamma}}\right) + \sigma \cdot e^{\bar{g} \cdot \gamma} \cdot \phi\left(\frac{\beta'\overline{X}}{\sigma \cdot e^{\bar{g} \cdot \gamma}}\right)$$

Where

$\beta, \gamma, \sigma =$ Estimated Coefficients
$\overline{X}, \bar{g} =$ Sample means of independent and heteroskedastic varaibles
$\Phi, \phi =$ Cumulative, and probablity density functions

(Maddala 1983)

E.3 The Delta Method

To estimate the 95% confidence intervals around E[WTP], the delta method, as recommended by Kirchhoff et al., was used. The delta method is based on the asymptotic distribution of a function. If f(b) is a continuous function, such that R=∂f(b)/∂b\` then;

$$f(b) \overset{a}{\rightarrow} N\left[f(b), R\left(\frac{\sigma^2}{n} Q^{-1}\right) R'\right]$$

Where $\left(\frac{\sigma^2}{n}Q^{-1}\right)$ is the asymptotic covariance matrix which is estimated by

$s^2[X'X]^{-1} = \Sigma$, which is the estimated variance covariance matrix that is calculated in the estimation of the WTP function(Green 1997). With this condition of asymptotic normality for the function f(b), the 95% confidence intervals can be calculated as follows:

$$CI_{95\%} = E[WTP] \pm 1.96\sqrt{R'\Sigma R}$$

With the heteroskedastic Tobit specification, 'R' is the derivative of the objective function is taken with respect to the regression coefficient (β), the heteroskedastic coefficients (γ) and the estimated standard error (σ).

$$R = [\partial f(\beta,\gamma,\sigma)/\partial\beta' \quad \partial f(\beta,\gamma,\sigma)/\partial\gamma' \quad \partial f(\beta,\gamma,\sigma)/\partial\sigma]'$$

$$\partial f(\beta,\gamma,\sigma)/\partial\beta = \Phi\left(\frac{\bar{x}'\beta}{\sigma e^{(\bar{g}'\gamma)}}\right)\bar{x}$$

$$\partial f(\beta,\gamma,\sigma)/\partial\gamma = \sigma e^{(\bar{g}'\gamma)}\phi\left(\frac{\bar{x}'\beta}{\sigma e^{(\bar{g}'\gamma)}}\right)\bar{g}$$

$$\partial f(\beta,\gamma,\sigma)/\partial\sigma = e^{(\bar{g}'\gamma)}\phi\left(\frac{\bar{x}'\beta}{\sigma e^{(\bar{g}'\gamma)}}\right)$$

(Kirchhoff et al 1997)

When calculating confidence intervals for a single site the independent variable means $(\bar{x},\bar{g})$, regression coefficients (β,γ,σ), and the variance-covariance matrix (Σ) specific to that site are used. When calculating the confidence intervals for a benefit function transfer (BFT), the independent variable means $(\bar{x},\bar{g})$ from the policy site are used with the regression coefficients (β,γ,σ), and the variance-covariance matrix (Σ) from the study site.

E. 4 Wald Test

The Wald test statistic is commonly used to test hypothesized restrictions on regression coefficients. In Chapter 5 the Wald test was used to test the restriction that coefficients estimated at the policy site were equal to those at the study site. Let $\hat{\theta}$ be the estimated coefficients and c(θ)=q be the set of hypothesized restrictions. If the restrictions are valid c($\hat{\theta}$)-q should be close to zero. The Wald statistic is:

$$W = [c(\hat{\theta}) - q]'(Var[c(\hat{\theta}) - q])^{-1}[c(\hat{\theta}) - q]$$

In large samples W has a chi-squared distribution, with degrees of freedom equal to the number of restrictions. Above, the two side terms simply equal the difference between study and policy site coefficients. And the middle term equals the inverse of the covariance matrix from the policy site. This is because:

$$(Var[c(\hat{\theta}) - q]) = \left[\frac{\partial c(\hat{\theta})}{\partial \hat{\theta}}\right] VAR[\hat{\theta}] \left[\frac{\partial c(\hat{\theta})}{\partial \hat{\theta}}\right]'$$

And because our restriction are simply $\hat{\theta}_{study} = \hat{\theta}_{policy}$, the partial derivatives of the restrictions with respect the coefficients are equal to 1. Leaving only Var($\hat{\theta}$), which is the covariance matrix from the estimated WTP function.

Appendix F Alternate Specification for Year Variables in the Hedonic Price Function

A suggested improvement for the hedonic price function specified in Chapter 4 regarded the binary dummy variables used to represent year of sale. It was noted that the implication of this specification was that expected sale price increased in a step wise fashion over time. This is in contrast to the expectation that market prices for homes fluctuate in an effectively continuous manor. In the weeks following the presentation of this thesis, an attempt to reconcile this divergence was made by changing the dummy variables for years, to a linear combination of two years that define the year and month of sale, and by including a variable that represented the mortgage rate that home buyers were facing during the month of sale. It was expected that this specification would better approximate the continuous changes in the housing market, and provide a better fit of the data. However, there was uncertainty as to the effect of this change on the coefficient of interest DISTANCE.

The linear combination of two years to specify the year and month of sale was first specified by Bryan and Colwell (1982), and was used by Spahr and Sunderman (1999) in a hedonic price study. This method uses a set of weighted time variables. The variables Year96, Year97, Year98, Year99, and Year00 each represent January first of that year. With these variables any year and month from January 1996 to December 1999 can be defined by assigning proportional weights to the two appropriate year variables. For example, if a home was sold in April of 1997, the variable Year97 would be assigned a weight of .75 and Year98 would equal .25. Note that this specification also results in a step like function. However, it much more closely approximates a continuous progression in housing prices than did the original specification of binary dummy year variables.

The month of sale was further characterized by including the average national mortgage rate in the preceding month. This variable, LAG30, was selected because of the expectation that prospective home buyers "lock in" this mortgage rates approximately thirty days in advance, and that the rate home buyers are paying should affect the amount they are able to afford. The data for this variable was downloaded from the United States Federal Reserve's web site http://www.federalreserve.gov/.

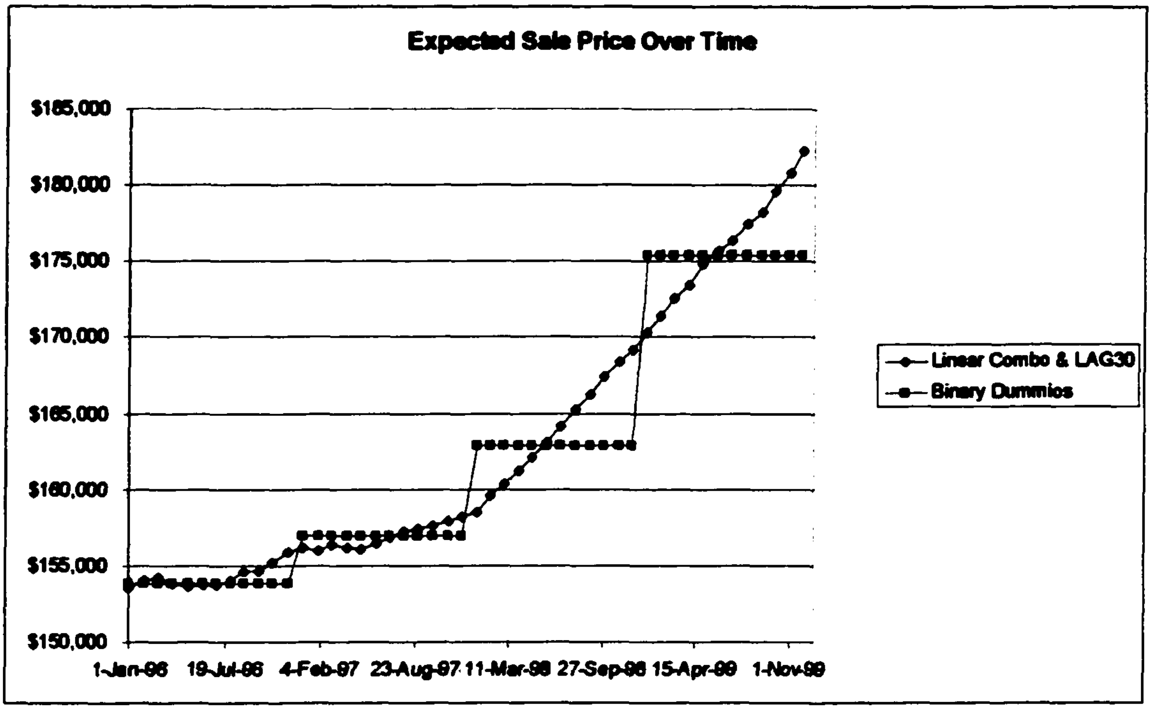
The regression results using the weighted year, and lagged mortgage rate variables and the double-log functional form are presented in the table below.

	Coefficient	Standard Error	T-Ratio	P-value
LAG30	-0.00802	0.010	-0.81	0.42
YEAR96	4.71823	0.099	47.63	0.00
YEAR97	4.73825	0.104	45.62	0.00
YEAR98	4.74921	0.097	48.86	0.00
YEAR99	4.81835	0.093	51.68	0.00
YEAR00	4.90088	0.105	46.49	0.00
lnAREA	0.16891	0.003	57.22	0.00
lnTOT_LIVE	0.71942	0.012	59.68	0.00
AGE	-0.00538	0.000	-22.92	0.00
lnBATH_FIX	0.10904	0.012	9.27	0.00
GARAGE	0.03945	0.003	13.43	0.00
lnDISTANCE	-0.04527	0.003	-17.43	0.00

$R^2 = 0.83786$

The R^2 value for this model is only slightly higher than for the original hedonic model in Chapter 4 (0.83694). All the year variables have very high t-ratios, indicating that this weighted variable set is accurately accounting for changes in the Tanque Verde housing market over time. The variable LAG30 is not significantly different from zero.

However, it does have the expected negative coefficient. The graph bellow illustrates how this alternate specification allows for a more continuous progression in home values, by graphing the expected value of an average home over time for both the new and original specification.



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