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16. Abstract

The objective of this research was to examine the effects that construction of a major highway has on the value of surrounding properties, a topic which is of great public concern. Information was obtained on actual sales prices, as well as the characteristics of the properties. Four residential study areas were used, and as many as 4,785 sales were obtained in each area. The information on building and neighborhood characteristics was used to generate a quality-adjusted price index. This index for the years during which a highway was opened was then compared with an index for an area which had been unaffected by highway change. The results show that when the highway significantly increased the accessibility of the residences, property values increased by 12 to 15 percent. Unfortunately, the houses closest to the highway had this increase partially offset by a .2 percent to 1.2 percent reduction for each 2½ dBA increase in the highway noise level. Houses with highway noise were not found to take any longer to sell. In a commercial-industrial area, land values were found to increase 16.7 percent when a major highway was opened. Interviews were conducted in both residential and commercial areas.

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ON PROPERTY VALUES IN WASHINGTON

RESEARCH PROJECT
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PREPARED FOR:

WASHINGTON STATE TRANSPORTATION COMMISSION
IN COOPERATION WITH
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SOCIAL AND ECONOMIC
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Chapter One

Introduction

Transportation projects, whether major construction or efficient management of the existing system, are being evaluated more carefully than ever during the planning stages. This attention to detail is well justified because the implications of such projects transcend the engineering disciplines and have environmental, social, and economic effects of major importance. In the economic area one of the impacts that is of great concern to the public is the effect of a highway on property values. The purpose of this study is to measure the beneficial and adverse effects of limited-access highways on property values. There is a need in the State of Washington for having current results on this subject that apply specifically to our state. In addition there have been several theoretical developments that allow refinement of previous studies and validation of their results. A number of these earlier studies are summarized in the following chapter.

There are numerous different causes of property value changes when a highway is constructed. These various effects can work in opposite directions and can occur over different areas and times. In this study the beneficial effects are measured by examining the property value trends in the affected area from considerably before the highway's opening to the present. These trends are then compared with a general residential real estate index for comparable property or an index in a control area to discover any differences. The trends within the study area are first established by using hedonic regressions to separate the value of a house into the value of the various components of that house. Once this is done, it is possible to establish the price trends when all the characteristics of a house are kept constant. The accuracy of the price index developed by this method depends on the accuracy of the specification of the regression equation which establishes the component prices. The specification used in this study avoids several problems which have hampered some of the other studies which have been done recently. Nonetheless, it was desirable to check the specification of the equation by comparing the index generated with an index created by a different method. Such an alternative method was provided by examining repeat sales on the same houses. By this means the various characteristics other than depreciation were constant, and the pure price changes could be measured. The two indexes were then compared to assure the reliability of the price index for the study area. These indexes were then compared with a control real estate price index to see if the highway had influenced the values of nearby homes. It was found that an improvement in accessibility due to new highway was reflected in an increase in property values.

A less desirable effect on property values is created by adverse highway influences which may affect certain houses. Noise is the most important of such adverse effects. Noise monitoring was done throughout the study areas. Using this data, the hedonic regressions revealed that property values were hurt by noise. The theoretical discussion points out what is and is not being measured by the noise coefficient in the hedonic regressions. An alternative means of estimating property value damages without noise measurement is carried out using more easily collected data on distance and elevation with respect to the highway and vegetative cover. These negative effects on property values must be compared with the positive effects of improved accessibility to discover the net effect.

Chapter Two contains a review of the most important studies done previously. The theoretical and empirical techniques which have been used in this study are discussed in Chapter Three. The main focus of this research is the effect of a highway on residential property values. Studies were done in a variety of areas to find how the effects differed in different types of neighborhoods and with different access improvements. Chapters Four through Seven discuss the four residential study sites and the results. A related issue is considered in Chapter Eight: the effect of a new highway on commercial and industrial land. Chapter Nine considers the commonly expressed hypothesis that the adverse effects are manifested not only in reduced prices but also in increased time required to sell an affected house. A theory is described that predicts that the length of time on the market would not in general be increased by highway proximity. Data on time on the market and reductions in price were obtained from a multiple listing real estate organization to test this theory. Finally, interviews were carried out with the occupants of properties in the study areas. The interviews revealed people's perceptions of the beneficial and adverse effects to nearby properties of the highway. Questions revealed the residents' feelings about the effect of the highway on property values and their overall evaluation of the highway. These results are reported in Chapter Ten. The results for the entire study are summarized in Chapter Eleven. The many possible applications of these results are also described there.

Chapter Two

A Review of the Literature

In the late 1950's new interest in the impact of highways on the surrounding communities was generated, partly motivated by the studies called for by the Highway Revenue Act of 1956. Many of these studies were concerned with the effects of highways on property values. These early studies utilized the techniques that were available at that time and in some cases were quite well done. However, the limitations on the methodology led to widely differing results. These early studies considered all property value effects to be motivated by accessibility benefits. During the 1960's the techniques available were improved. Some of the adverse effects of highways on properties were considered more adequately, and several studies focused exclusively on these effects. Recently attempts have been made to quantify both the beneficial and adverse effects of highways using regression techniques. This evolution in the land value literature is summarized in this chapter.

Among the best of the early studies are the ones carried out in Dallas, Houston and San Antonio which are summarized in Adkins (1959). These studies used data on real estate sales that took place both before and after a highway was opened. The change in the prices after the highway was opened were adjusted for general trends in property values by selecting control areas and examining value trends there. These studies considered both the actual sales prices and an approximation of the unimproved land value obtained by subtracting the assessed value of the improvements from the sales prices. In Houston and Dallas the results were very comparable. When the sales prices were adjusted for the value of the improvements, that land adjoining the freeway appreciated 450 percent more than land in the control area. For the unadjusted prices the appreciation ranged from 150 to 300 percent. The value of the land over four blocks away from the highway was uninfluenced by the highway. The studies also found that the effects took place after the highways were open, rather than when the construction was announced. The San Antonio study presented its results in a different form by considering the land use. Manufacturing land was influenced the most with about 200 percent appreciation while single-family residential land was insignificantly effected.

There are several problems faced by these three studies. Of major importance is selecting a control area that is truly comparable in all respects other than the highway. Any other influences that differ between the areas will lead to errors in measuring the effects of the highway. A second problem lies in adjusting the selling prices by the assessed value of the improvements. Assessed values are often inaccurate indicators of true market value, and, since there are three or more years between reassessments, there is a substantial lag between the market and the assessment. The alternative to this required information about the improvements on the property. A rough move in this direction was provided by the San Antonio study's separation of land uses, but the study then had to resort again to assessed values within classes. The studies Adkins discussed provided important first steps but were also faced with important problems.

Another study in the same vein was done by Bone and Wohl (1959) as part of their "Massachusetts Route 128 Impact Study." They also made use of control areas and before-after techniques. Their main innovations were three: restriction of the study to residential property, examining yearly averages to ascertain the timing of the effects, and the use of a residential building cost index as well as a control area. Because of problems similar to those Adkins faced, their results were mixed. In one community the highway seemed to have caused property values to appreciate, but this effect fluctuated widely from year to year (from about 15% to 0% and back to 24% in one three year period with similar jumps in other periods). In the other community the highway seemed to have had little effect, although values in the two areas again seemed to vary randomly. In each of the study areas the effect of distance from the highway also seemed subject to random fluctuations. One positive point is that in both areas the control seemed to follow the construction index quite closely.

A similar study was done in Colorado about the same time by Bardwell and Merry (1960). Much of the area they examined was rural, but they also had a subgroup of developed and undeveloped suburban land. They used the consumer price index to deflate sales prices rather than utilizing a control area. Sales were only considered during two time periods. Their results for suburban land were mixed with unimproved parcels appreciating substantially but improved land actually depreciating. The study encountered similar problems to the Adkins work, and in addition the consumer price index often follows different trends than the residential real estate market in a specific city.

A later study by Cribbins, Hill and Seagraves (1965) looked first at average sales prices as these previous studies had and found similar results. However, they went beyond this point by using regression analysis to attempt to explain the prices. While this is certainly the promising direction to take, there are certain shortcomings in their analysis. The two highway variables they include are the distance to the highway and the distance to the interchange. When these variables have coefficients that are generally not significantly different from zero, they conclude that the highway has not had any effect on property values. Yet the distance to the highway may be significant within a limited range where noise is present. But when data on houses more distant are included where highway distance is irrelevant this masks the relationship in the impact zone. This explains why the first coefficient is irrelevant. Secondly, for commuters the distance to the interchange is a minor factor in the journey-to-work time. So the highway may have had significant access benefits, but they will not be revealed by the second variable. These problems weaken the results, but the techniques used were better than in the earlier studies.

However, one early study which used regression techniques as well as more traditional methods was done by Wheeler (1956). This study examined the effect on property values on Mercer Island and east of Lake Washington when a bridge was constructed which linked them to Seattle and reduced travel time to the central city by ten to twenty-five minutes. The more traditional analysis selected control zones for the two study areas and then compared the appreciation in the study and control areas for various types of properties. The subgroups used included improved and unimproved property, various time savings zones, various distances to the improved access, waterfront and inland property, and various other characteristics. One difficulty encountered was that there was a toll on the bridge for nine years after its opening. For this reason these intermediate years were omitted from the study. Since the before and after periods then encompass a wide time span, the comparability of the control areas becomes especially crucial. The same pitfalls apply here as in the other studies discussed thus far.

The alternative technique used was more innovative. Regression analysis was used to attempt to explain real estate market prices using such variables as access, property improvements, community facilities, and land quality. Without the later computer technology, Wheeler was forced to limit the number of variables and cases which may have led to an incorrect specification of the regression equation. However, this study represented early first steps with this promising technique. The two techniques derived estimates ranging from 70 to 118% appreciation due to access improvement for the east side of Lake Washington. On Mercer Island comparable estimates ranged from 120 to 154%.

Subsequently Mohring (1961) used part of Wheeler's data in order to test his theoretical model of the effect of highway improvements on land values. He restricted his sample to sales of unimproved, inland property that took place after the toll on the bridge was removed. He used regression analysis to attempt to explain the price per square foot of land with variables such as travel time to downtown Seattle, year of the transaction, size of the property, distance to the lake, and whether or not it was in a developed area. The functional form with which he entered some of the variables is questionable, and the explanatory power of the equation is low, but the model has provided a springboard for later studies.

A similiar study of the effects of accessibility on real estate prices was carried out by Pendleton (1963). That study found that similar results were obtained using different measures of accessibility, and Pendleton points out a mistake in Mohring's derivation of an estimate of the value of time. However, for the purposes of this study the main point of interest is that Pendleton developed a well-specified hedonic regression to analyze the effect of accessibility on property values. The regression includes such important variables as square feet of living space, style of house, number of bathrooms, and so forth. Such a specification is excellent and superior to that used in several later studies which were unable to obtain such important data. The only variable which should not have been included is income, but this was a mistake common to almost all hedonic regressions until very recently. Pendleton's accessibility coefficient represented a $63.68 reduction in price for each additional minute of driving time to the central business district, a value which is quite close to Mohring's.

By the 1960's there was a growing concern with the harmful effects to certain properties that highways may yield as well as with the benefits measured by the earlier studies. Two studies by Colony

(1966, 1967) were among the first to be concerned with the effects of freeway noise on adjacent properties. In estimating the changes in property values at various distance back from a highway, Colony felt he had shown that properties within fifty feet of the highway were adversely effected and thus appreciated more slowly. But those properties between 50 and 200 feet appreciated even more rapidly than properties further removed from the highway. However, there were several problems with the study. First, he relied on assessed values rather than market sales. He examined some sales to see their relation to assessed value. Yearly regressions of these two values revealed coefficients varying from .251 to .441 with R^2 as low as .41. Yet he based the analysis on assessed values adjusted by these regression values, thus reducing the reliability of the study. Secondly, a major segment of the study concerned the initial sale of lots in a new development. Yet one developer's opinion of appropriate prices can hardly be taken as representative of the real estate market, and in fact lots next to the highway sold at a much slower rate than those further back which indicates that a market clearing price had not been established. In another section of the study a chi-square test was used to discover if there was a significant relationship between noise levels and those properties that were estimated to have appreciated by more than 1000%. It was found that the quieter houses appreciated significantly more often in at least half the areas studied. Thus there was some evidence that noise adversely affected some houses, but certain problems in the study prevented any general conclusions.

At about the same time Towne and Associates (1966) carried out a study of the effects of freeway noise on apartment rents. This study contained several improvements in technique over the Colony studies, but again a crucial problem may reduce the reliability of the results. The improvements over the Colony work that the Towne study made lie in the improved noise measures and the use of regression techniques. The noise measures used by Towne they called high mean and energy average. The high mean represents the mean of the highest five percent of the noise levels and the energy average is a weighted average of what now are called L_{eq} readings. These two readings are thus roughly equivalent to L_{10} and L_{eq}, as discussed in Chapter Four. They use stepwise regressions to select the variables from a list that contains apartment and location characteristics as well as various measures of freeway noise. Their results indicate that effects of freeway noise on apartment rents are minor, often statistically insignificant, and at times enter the equation with a sign opposite the one anticipated.

These results contradict those found in several other studies. They cannot be explained away by indicating that they apply to rents rather than to the sale prices used in the other studies, as Nelson (1975) does. The sales price of house simply represents the capitalized value of future implicit rents that it can command. If noise is a factor in the price, it must also be a proportionate factor in the rent. If it is statistically significant in one price, it would also be statistically significant in the other, unless renter's tastes differ systematically from those of homeowners and long run equilibrium has not been attained. A more likely explanation is that the stepwise regressions entered variables that measure noise in as many as seven different but related forms. In this situation it is likely that the problem of multicollinearity will arise, which causes the variance of the estimates to increase. This could account for the insignificance and instability of the noise results.

The negative highway proximity effects of property values were also considered in part of the Brinton and Bloom (1969) report. Their major concern was with landscaping's impact on adverse highway effects, but they also examined the effects of distance from the highway and highway noise on property values. Using resales on properties, they examined whether the rate of appreciation of property values was greater for houses more removed from the highway. Using maximum noise readings they found a weak negative correlation between noise levels and property appreciation. There appeared to be no significant relationship between highway distance and property values changes. However, the study only examined sales that took place after the highway was opened. It seems reasonable that noise has a definite initial effect on property values, yet after that the properties might well appreciate at the same rate in percentage terms as those further back from the highway. Thus, the results of this study are not indicative of an insignificant effect of the highway on property values.

Some more recent studies have again considered the impacts of beneficial access improvements on property values. A series of studies (Allen and Boyce, 1974, Boyce et al., 1972, Mudge, 1974) were done on the impact of the Philadelphia-Lindenwold High Speed Line on property values in the residential area communities served. They made use of the previously discussed before-after, study-control methods, but these techniques were refined through the use of regression techniques. The theoretical model being tested was a modification of the one developed by Mohring (1961). They treated discrete stations rather than the continuous highway in Mohring's model. The model was then tested by using data on over 24,000 property transactions to attempt to explain price with site, neighborhood, locational and impact variables. Data from the study and control area were aggregated together, and dummy variables were then used to distinguish sales in the study corridor after the line opened, sales in the control corridor after the line opened, and the combined sales in both corridors before the line opened. The large data base created some of the problems the study faced since it was too expensive to obtain data on some of the independent variables they should have included. Thus, their site characteristics did not include living space, lot size, number of baths, or other important attributes. In addition they did not limit their data to residential use even though some of their site characteristics were relevant only to houses. They included land use variables, but some of the coefficients can no longer be interpreted. Their neighborhood characteristics were based on the census data with the greatest explanatory power. Sales in the Lindenwold corridor after the line opened were assumed to include the dollar savings commuters received from the line, although they ignored the value of time.

The regression estimated the effect on property values of each dollar saved by using the Line for a roundtrip. Each dollar saved gave rise to a $149 increase in property values. The control dummy variable had a coefficient that was not statistically significant.

When the data was divided into three time periods, the property value effect seemed to take place after the line opened. The coefficients for the late construction period were contradictory and difficult to explain.

It is interesting to note that the Lindenwold impact of $149 per house for each dollar of savings per trip has surprising implications. If one person in a house commutes to and from work 250 times a year this means that property values increase by $149 for annual savings of $250. This means that the resident's implicit discount rate is 168% instead of the five to ten percent rate implied by market interest rates. If the value of time were considered, this would become even worse. This implies that the residents are irrational, or only slightly influenced by the savings, or ignore the savings which eliminates the usefulness of the model. The alternative interpretation is that the regression equation is not correctly specified.

A series of studies carried out in urban communities near the nation's capitol are probably the closest to the spirit of the present study. Gamble, et.al. (1973, 1974) analyzed the adverse and beneficial effects of urban Interstate highways on four communities in New Jersey, Virginia, and Maryland. The access benefits were estimated by regressing house characteristics and an accessibility index on house prices in Fairfax County, Virginia. The study areas were primarily selected to analyze the adverse effects suffered by the residences. Data were collected on both noise and air pollution at the various locations. This information was combined with home and occupant characteristics to explain the observed market prices. The measure used for noise was the Noise Pollution Level index suggested by Robinson (1971). This index uses the "energy mean", L_{eq}, and adds a factor which depends on the variability of the noise level. (See Chapter Four.) The regressions for the various communities yielded estimates that ranged from $60 to $646 reduction in property values for a one decibel increase in the index. A combined regression for the four areas obtained an aggregate estimate of $82. An additional facet of the study involved interviews with the residents to determine their reactions to the adverse effects.

This study has proven extremely important because it was the first time that the various elements of highway-induced property value changes were included in a single study. Both the beneficial and adverse effects were treated in a fairly unified framework, and the market data results were compared with residents' perceptions of the effects. Their widely quoted results have proven to be in fairly close agreement with those of other recent studies.

It is unfortunate that the data with which they had to work contained certain shortcomings. Information was not available on crucial housing characteristics such as square feet of living space. Because these important variables are left out, the estimates of the coefficients may be biased. In addition the variables to be included in the regressions were selected empirically using stepwise techiniques. Because of this, one area utilized only two independent variables other than noise while another used seven different variables. The specification of the equations is thus not robust. A second problem arises from the fact that in two of the areas there were a very limited number of observations where the noise level was above ambient. The smallest sample size was 32, of which only about one-fifth had noise levels above ambient. In spite of these problems the study represents an important improvement over the previous methodologies.

Closely related studies based on related data were carried out by Langley (1976a, b). He compared real estate price trends in proximity to the highway to the trends in prices for houses further back. He concluded that houses next to the highway appreciate at a slower rate than those further back but that a statistical difference can only be verified for the most recent years of the study.

Several comments are in order. First, as in the case of the Brinton and Bloom report, all the data were from the years after the highway was opened. While it is of interest to compare the trends during this time, such a study may not capture all of the adverse effects since the major effect on absolute prices probably occurs upon the opening of the highway. The data misses this effect.

Secondly, the years in which the indexes are significantly different, according to the t-test Langley used, depend on which year is chosen to normalize the indexes. Suppose there is a constant difference in the trends of the two indexes and that the standard error of the estimates is constant between years. In the year of normalization the two indexes are forced to be equal. If housing prices away from the highway appreciate one percent a year more than those next to the highway, it may be several years before the difference becomes large enough relative to the constant standard error to reject the hypothesis of equivalence. Thus only in the most recent years do the indexes seem to statistically differ using the t-test. If the indexes had been normalized on the most recent year, Langley probably would have found that the indexes only significantly differ in the early years. A more appropriate test would be a Chow test to see if aggregation of the data from the two areas would be legitimate. Also, the number of observations that Langley used appears to be the number of sales in that year rather than the number of sales-pairs upon which the regression is based. This would influence the significance tests. A related comment concerns his use of the Durbin-Watson statistics to see if the errors are generated by a first-order Markov process. For this to be meaningful there must be a logical ordering of the observations, such as with time series data. With Langley's data on sales-pairs there is no such ordering since the pairs can span any number of years. Thus the Durbin-Watson test is meaningless in this situation. Langley's application of regression techniques to developing price indexes is innovative, although these comments weaken some of his conclusions.

A final study that is related to the ones discussed here was made available only recently. Anderson and Wise (1977) have used Gamble's data to reexamine these issues in light of recent theoretical developments. Since the failings in the data were the most important problems Gamble, et.al. faced, similar problems affect the Mathtech study. However, the theoretical section in the work discusses many of the issues that such studies must consider. They seek a specification of the hedonic equation which is robust enough to use in each of the study areas. Because of the data shortcomings they are unable to do so, but nonetheless derive an estimate of $75/dBA reduction in property values which is quite comparable to the estimates in other studies. However, in three of the four areas the noise coefficient is not significantly different from zero. Their theoretical discussion of the specification of the regression equations will be discussed later in this report, but their non-linear estimation of the equation has interesting possibilities except for the current expense of such estimation. Their work on accessibility effects is less successful, since the data only provides them with four observations based on the four study areas.

Nelson (1975) has carried out a careful study on the property value effects of accessibility and various environmental factors. The hedonic regressions are well designed and incorporate recent theoretical developments. He discusses the differences between the hedonic gradients and the demand curves for environmental improvements, although he did not attempt to estimate such demand curves. The major difference between his study and those discussed previously was in his use of census tract data rather than data on individual sales. For many of his purposes his data was more promising for revealing the effects he was studying. For example his accessibility estimate was quite robust and was comparable to the estimates from other sources. However, the effects of traffic noise are more localized than census tracts, and thus his estimates concerning traffic noise must be approached with caution. He simulated the traffic noise by using traffic data as an input to a computer program, but such noise prediction programs are still in a developmental stage and are often inaccurate. And even if they were accurate, the effects would apply to houses within a few hundred feet of the highways and not to entire census tracts. It is somewhat surprising that his result of a $58 decrease in property values for each 1 dBA increase in noise was so close to the estimates of studies discussed previously.

Vaughan and Huckins (1975) used data on individual transactions to assess expressway noise damages although they were unconcerned with accessibility benefits. They made use of well-specified hedonic regressions for residential sales in the Chicago area. Their results indicate that a 1 dBA increase in traffic noise above 50 dBA results in a reduction of approximately $150 in the value of that home. The noise variables that they used were an index of the energy level which is equivalent to L_{eq} and a comparable index based on pressure levels which they found to have more explanatory power. They took 50 dBA as the base below which noise level differences made no difference rather than determining the ambient level. The study used an unnecessarily complex method to convert the semilogarithmic regression coefficients to damage estimates, but this was one of the few shortcomings in a carefully designed study. However, since their observations were spread out over the Chicago area, there was more chance of neighborhood differences being unaccounted for in the regression.

The techniques used in the various studies are summarized in Table 2-1.

TABLE 2-1. SUMMARY OF PREVIOUS STUDIES

	Considered beneficial access effects	Considered adverse environmental effects	Adequate theotetical model	Disaggregate data	Aggregate data	Adequate noise data	Appropriate statistical tests	Utilized hedonic regression techniques	Utilized resale regression techniques	Adequate equation specification
Adkins (1959)	X			X						
Bone and Wohl (1959)	X			X						
Bardwell and Merry (1960)	X			X						
Cribbins, et al. (1965)	X			X						
Wheeler (1956)	X			X				X		
Mohring (1961)	X		X	X				X		
Pendleton (1963)	X			X				X		X
Colony (1966, 1967)		X		X						
Towne (1966)		X		X		X		X		
Brinton and Bloom (1969)		X		X						
Boyce, et al. (1972, 1974)	X		X	X				X		
Gamble, et al. (1973, 1974)	X	X		X		X		X		
Langley (1976a, 1976b)		X		X					X	X
Anderson and Wise (1977)		X	X	X		X	X	X		
Nelson (1975)	X	X	X		X		X	X		X
Vaughan and Huckins (1975)		X		X		X	X	X		

Chapter Three

The Theoretical Model and Empirical Framework

To determine any beneficial access effects from a highway, there are two courses of action available. It is possible to carry out a cross-sectional study of residences in significantly different locations and relate the various property values to some measure of the accessibility of the location. The alternative is to examine time-series data of property values in a particular area for a number of years before and after a highway is opened, and compare the trends with those in an area relatively unaffected by changes in the highway system during the same period.

The former method requires a measure of accessibility such as the percent of employment that is reachable within 45 minutes (Gamble, 1973, or Nelson, 1975) or travel time to the central business district (Nelson, 1975). Travel time to the central business district (CBD) is a reasonable measure of accessibility on the hypothetical featureless plain where all employment is in the CBD as postulated by many urban models. For more realistic urban areas, it is necessary to use more complex accessibility indices which take into account the attractiveness between various zones as well as the travel costs between these zones. The study by Gamble, et al (1973) uses such an index, but the index does not vary within a given study area. In effect their four study areas yield only four observations for a cross-sectional study. For this reason they are forced to carry out a separate accessibility study with separate data. The study was restricted to 59 properties scattered throughout one county. Enough variation in accessibility was provided, but the limited number of observations reduces the reliability of the results since residential properties are so heterogeneous. Because of the large area that must be included in studies of this type, expense may rule out studies of individual houses and force studies of census tracts such as Nelson's (1975). Finally, the necessary accessibility indices are generally only available at wide intervals, and this makes prediction of the accessibility effects of a particular highway improvement difficult.

The alternative method, which has been selected for this study, examines the time pattern of property values in an area bisected by a highway. This technique allows the use of data on individual houses, which makes possible the simultaneous consideration of localized adverse highway effects such as noise or air pollution. In addition, not just the final effect on property values is observed, but also the pattern of change before the values again stabilize. Finally, this method examines property values in the period before the highway is opened which allows the researcher to check the specification of the model before the major change of the highway was introduced and to see if expectations of the highway's opening caused property value increases to anticipate the construction of the facility.

The Development of Real Estate Price Indexes

In this study, two of the means used to ascertain the time pattern of property values are based on hedonic pricing, a technique introduced by A. Court (1939) and refined by Griliches and others (1971a) which evaluates quality changes in products by separating a commodity into its various characteristics and studying the contribution of each characteristic to the object's value. Thus price is a function of these characteristics, and multiple regression techniques are used to find the effect that changing one feature has on price when all other aspects of the good are held constant. The details, both theoretical and empirical, of the particular specification selected are discussed in detail later. Here we will assume that the equation is correctly specified and concentrate on the time aspect of the problem.

Dummy variables, variables which take a value of one in a particular year and zero otherwise, are the key to developing hedonic regressions spanning several years. If the data span T years, the first alternative is to take pairs of years, t and t+1 with t=1,2,...,T-1, and estimate the equation

$$p = \alpha + \sum_{i=1}^{n} \beta_i x_i + \gamma D_{t+1} + \varepsilon \qquad (3.1)$$

where P is some function of the price for which a house sold; the X_i are the n structural, site and neighborhood characteristics; D_{t+1} is a dummy variable that takes the value 1 if the sale took place in the second year and zero if the sale took place in the first year; and ε represents the error terms. Regression techniques allow estimating the coefficients α, β_i and γ.

If the equation is estimated in semilogarithmic form,

$$\ln p = \alpha + \sum_{i=1}^{n} \beta_i x_i + \gamma D_{t+1} + \varepsilon \qquad (3.2)$$

the estimate of γ can be used to estimate the percentage change in price with the characteristics held constant between the two years. The price index in year t+1 (normalized in year t) is equal to exp γ (see Halvorsen and Palmquist, forthcoming). This technique is acceptable any time the dependent variable is in logarithmic form, regardless of the form of the independent variables. If the dependent variable enters linearly then the time dummy variables would attribute the same absolute change to all houses regardless of value. Alternative means of developing indexes in such situations might be desirable.

When the percentage change in price between each contiguous pair of years has been estimated, a price index series can be created by combining these estimates multiplicately. This provides an estimate of the price changes when all the characteristics of the houses other than time are held constant.

An alternative means of generating such an index using a hedonic regression is to aggregate all data for the various years and run a regression using dummy variables for T-1 of the years. The equation might be estimated in semi-logarithmic form, such as

$$\ln p = \alpha + \sum_{i=1}^{n} \beta_i x_i + \sum_{j=1}^{T-1} \gamma_j D_j + \varepsilon \tag{3.3}$$

where the D_j represent the T-1 yearly dummy variables. The price index in year j is equal to exp γ_j. The base year for the index is the year where the time dummy varible is omitted. Linear forms of the dependent variable would again require alternative techniques.

This technique requires aggregating the data for all the various years. For this procedure to be valid, the true coefficients exclusive of those for time dummy variables and constants must be equal for all the subsets that are to be aggregated together. A test of the hypothesis that the coefficients are equal has been derived by Chow (1960) and expanded by Fisher (1970). The sum of the residual sums of squares for the individual regressions will always be less than or equal to the residual sum of squares for the aggregate equation. The test suggested by Chow determines if the reduction is statistically significant. The test statistic is

$$F = \frac{SSE_A - \sum_{i=1}^{j} SSE_i \,/(j-1)p}{\sum_{i=1}^{j} SSE_i \,/\, T-jk} \tag{3.4}$$

where SSE_A is the residual sum of squares for the aggregate regression, SSE_i is the residual sum of squares for the regression on group i, T is the number of observations in the total sample, j is the number of groups that are regressed separately, k is the number of parameters including the constant that are estimated in each of the individual regressions, and p is the number of parameters assumed to be equal. This statistic follows the F distribution with (j-1)p and T-jk degrees of freedom for the numerator and denominator respectively. If the statistic is less than the table value, one cannot reject the hypothesis that the coefficients are equal in the individual regressions.

There have been certain misgivings expressed about the use of time dummy variables described above. While Griliches (1971c) used this technique extensively, in a later article (1971b) he has expressed doubts about the soundness of the method. The problem lies in the fact that in order for the dummy variable coefficients to be unbiased estimates, the estimated equation must be correctly specified. If there are variables that belong in the true equation that are not included in the estimated equation, then the estimated coefficients will be biased. In Griliches' study of automobiles, this problem may well be substantial and reduce the validity of his results. In the housing market one can have more faith in the specification of the equation since fewer model changes are involved and long-lived capital goods are being studied. None the less, it would be reassuring to verify the results obtained with some alternative technique.

Such an alternative means of deriving a price index for heterogeneous capital goods is provided by the method suggested by Bailey, Muth, and Nourse (1963). Here the problems of completely describing the characteristics of a house are avoided by considering only properties for which there are repeat sales. The change in price between two sales on the same piece of property is obtained for property within the study area with more than one sale. These changes are then combined by regression methods to yield the desired index.

Formally this method can be explained as follows. For a single pair of sales on a piece of property, i, the ratio of two sales prices is

$$\frac{P_{it'}}{P_{it}} = R_{itt'} = \frac{B_{t'}}{B_t} \times U_{itt'} \qquad (3.5)$$

where $P_{it'}$ is the final sales price, P_{it} is the initial sales price, $R_{itt'}$ is the resulting price relative, $B_{t'}$ and B_t are the true but unknown indexes in periods t' and t , and Urepresents the random error of the price ratio from the true index ratio. Taking the natural logarithms yields

$$R_{itt'} = -b_t + b_{t'} + u_{itt'} \qquad (3.6)$$

where the lower-case letters represent the logs of their upper-case counterparts. To combine the various sales pairs, introduce a matrix X which is n × T if there are n sales pairs which take place in T years. Each row of the matrix corresponds to a particular sales pair. The elements of that row are +1 in the year of the final sale, -1 in the year of the initial sale, and 0 otherwise. The resulting equation is

$$r = Xb + u \qquad (3.7)$$

and each equation for a single sales-pair, $r_{itt'}$, is of the form expressed in equation 3.6. This is a typical multiple regression, and the derived coefficients are estimates of the natural logarithms of the price indexes in the various years.

Depreciation raises one possible problem with this technique. Between two sales of a piece of property, age may have decreased the property's value even though other factors may well have increased its value. Thus, by ignoring age the index understates the price increase if age could be held constant. Unfortunately, attempts to include the length of time between sales in this resale equation run into problems of multicollinearity.

In Palmquist (1979) it is shown that it is necessary to use an independent estimate of depreciation to adjust the price relatives and isolate pure price change. The price at the time of the second sale is adjusted using the hedonic estimate of depreciation and the length of time between sales. Using this adjusted price relative, the resale equation is estimated as before.

An additional possible theoretical problem raised by Bailey, Muth, and Nourse concerns the error specification when there are more than two sales on a particular piece of property. For ordinary least squares to yield minimum variance estimates, there must be no covariance of the error terms. But if there are multiple sales pairs on a particular piece of property, there may well be covariance of the error terms for equations pertaining to the same piece of property.

If the natural logarithm of the price of the i-th piece of property at a sale at time t , P_{it} , is a function of various characteristics, C_j, and a randomly distributed residual ε_{it}, then this relationship can be expressed as

$$P_{it} = f(c_j) + b_t + \varepsilon_{it} \tag{3.8}$$

where b_t represents the period effect. Later sales of the same house would result in new prices generated by the same equation for times t', t", etc. It is assumed that the residuals have zero mean, constant variance, and are uncorrelated with each other. The equations for the price relatives with three sales would be

$$r_{itt'} = p_{it'} - p_{it} = -b_t + b_{t'} + (\varepsilon_{it'} - \varepsilon_{it}) = -b_t + b_t + v_{itt'}, \quad (3.9)$$

$$r_{itt''} = -b_t + b_{t''} + (\varepsilon_{it''} - \varepsilon_{it}) = -b_t + b_{t''} + v_{itt''}, \quad (3.10)$$

and

$$r_{it't''} = -b_{t'} + b_{t''} + (\varepsilon_{it''} - \varepsilon_{it'}) = -b_{t'} + b_{t''} + v_{it't''}. \quad (3.11)$$

Since the residuals in the price equations all have common variance, then the price ratio equations also have residuals with common variance equal to twice that in the former equations. However, the covariance terms are no longer zero. Covariance of terms involving differences can be expressed as

$$\begin{aligned} \text{cov}\ (x_1-x_2, y_1-y_2) &= E[x_1y_1 + x_2y_2 - x_1y_2 - x_2y_1] \quad (3.12) \\ &- [Ex_1Ey_1 + Ex_2Ey_2 - Ex_1Ey_2 - Ex_2Ey_1] \\ &= \text{cov}(x_1,y_1) + \text{cov}(x_2,y_2) - \text{cov}(x_1,y_2) - \text{cov}(x_2,y_1) \end{aligned}$$

Thus

$$\text{cov}(v_{itt'}, v_{itt''}) = \text{cov}(v_{itt''}, v_{it't''}) = \text{var}(\varepsilon_i), \quad (3.13)$$

and

$$\text{cov}(v_{itt'}, V_{it't''}) = -\ \text{var}\ (\varepsilon_i). \quad (3.14)$$

If the specification of the distribution of the ε's is true, all covariance terms can be evaluated. In this case it is possible to obtain minimum variance estimates by using Aitken's estimator

$$\hat{b} = (X'\Omega^{-1}X)^{-1}\ X'\Omega^{-1}\ r \quad (3.15)$$

where Ω represents the variance-covariance matrix of residuals, r and b are vectors corresponding to $r_{itt'}$ and b_t, and X is as before. However, this matrix must be written in full, as opposed to the usual case of generalized least squares where a single parameter specifies the whole matrix when the errors are generated by a first-order Markov process. If the number of properties considered is large, the calculations become burdensome. And there is no guarantee that the original error specification is correct.

For these reasons, it would be attractive if ordinary least squares techniques could be applied without affecting the results significantly. The most reasonable test of this hypothesis would be through Monte Carlo studies. At a much less exacting level, it is possible to simply examine how many covariance terms are involved in actual cases. This certainly does not provide a proof of the acceptability of the procedure, but does give the researcher some idea of the number of non-zero terms in the covariance matrix. If all the pieces of property considered have an equal number of sales, n, and there are k pieces of property being considered, then there are

$k\frac{n(n-1)}{2}$ sales pairs to be studied. If all the covariance entries were 0 in the variance - covariance matrix, this would be $\left(\frac{kn(n-1)}{2}\right)$ $\left[\frac{kn(n-1)}{2} - 1\right]$ terms that were 0. The non-zero terms that arise from multiple sales are $\left[\frac{kn(n-1)}{2}\right] \left[\frac{n(n-1)}{2}\right]$ in number. Thus, a close approximation for the fraction of covariance terms affected is 1/k.

If different properties have different numbers of repeat sales, the formula becomes slightly more complex. But the results are very similar. Thus for any sample that contains over 100 properties, less than one percent of the covariance terms are affected. In the Kingsgate study to be reported subsequently there were 1021 properties with two sales, 291 properties with three sales, 57 with four sales, and 11 with five sales. This resulted in less than .02% of the covariance terms being non-zero, and ordinary least squares was used with few misgivings.

The Estimation of Adverse Highway Effects

The discovery of any adverse effects of highways on surrounding property values requires separating all of the factors influencing these values. This can best be achieved through the use of hedonic regression techniques. A collection of representative studies using these techniques is provided by Griliches (1971a). The method of hedonic regression is also necessary in developing price indexes by the first techniques discussed previously.

Hedonic pricing regresses the prices of a heterogeneous group of similar products on the various characteristics that yield value to the products. A typical equation would be

$$p_i = \alpha + \sum_{j=1}^{n} \beta_j x_{ij} + \varepsilon \qquad (3.16)$$

where p_i is the price of the i-th commodity and the x_{ij} are the j relevant characteristics. The estimates of the β_j provide estimates of the effect on the price of varying the j-th characteristic while holding all other characteristics constant. Two crucial problems face the researcher in developing an equation of this type. First, the characteristics must be correctly selected. If any relevant characteristics are omitted, the estimates of the other coefficients will be biased. If irrelevant characteristics are included, the estimates of the other parameters will be unbiased but their variances will be greater than when the equation is correctly specified. The only exception to this would be if the irrelevant characteristics were completely uncorrelated with the true characteristics. Second, the appropriate functional form must be selected.

The first problem has been a crucial short-coming of many studies of the effects of environmental factors on property values. In studies of highway effects specifically, Gamble, et. al. (1973) have a number of left-out variables that probably lead to bias in their estimates. This has been pointed out by Anderson and Wise (1977), but since their study works with the same data base they cannot escape these problems.

Some indication of the structural characteristics that affect price is provided by the Marshall and Swift Residental Cost Handbook, a widely used aid for making appraisals. As expected, this handbook considers the number of square feet of living space to be the most important determinant of cost. Marshall and Swift also find that the value of living space differs between one, one and a half, and two-story houses, and between different qualities of houses. Other important features are the number of plumbing fixtures, fireplaces, and built-in appliances, as well as basement and garage areas. Examination of assessors' records strengthen these presumptions since they record similar data.

These sources substantiate the a priori belief that characteristics such as these, together with age, form the structural component of the regression equation. Value also was expected to be influenced by neighborhood characteristics such as distance to parks, schools and shopping and the availability of subdivision-owned recreation facilities.

The final expected variables were highway-related factors. Accessibility would be expected to enter positively, while environmental problems are expected to have a negative effect on property values.

A further question in variable selection concerns the exact form in which the variable enters the equation. Some variables such as quality or age may have to be weighted by the area of the house. When this weighting is done, quality is worth more or depreciation greater (both in absolute terms) in a large house than in a small one (See Grether and Mieszkowski,1974). Decisions such as these can be based on maximizing R^2 when no distinction can be made on theoretical grounds.

The second problem in the specification of the equation is the choice of functional form. The decision must be made whether the usual linear form for the equation is adequate or if the true equation can be better approximated by some alternative form such as semi-logarithmic. There are two steps in making this decision. First, theoretical considerations may dictate that a particular form be used. In this case the search can stop here. However, if the theory does not specify the form, it becomes a question of which form is empirically most appropriate.

A theory concerning the appropriate functional form has been advanced in the Anderson and Wise study (1977). They argue that a house is a malleable capital good. Space can be added, as can bathrooms. Basement or attic areas can be finished. Because of this malleability, the hedonic price of a characteristic is constrained to be less than the cost of adding the characteristic to an existing house. They dismiss waiting costs as being unimportant to the marginal buyer, and feel that the pressures of growing population and increasing real income will force characteristic values to this upper constraint.

Even if waiting costs can be ignored, there are certain nonlinearities in construction costs that tend to weaken this argument. The cost of a square foot of living space is not a constant as they suppose, but rather this cost decreases as the living area increases. This view is substantiated by Marshall and Swift's cost estimate methodology. Thus the cost difference between constructing new houses with 2,000 square feet and 2,100 square feet is considerably less than the cost of adding 100 square feet to an existing structure. As long as there is undeveloped land relatively close to the population centers, this cost difference may not be competed away. Similarly, adding a bath to an existing structure is considerably more expensive than building it in at the time of construction. Thus, the value of characteristics is not constrained to the cost of changing the malleable good, and in fact there are probably considerable nonlinearities involved in specifying the structural components of the equation. This is not to deny that valuable information is gained by comparing estimated coefficients to construction costs in order to see that the equation is correctly specified. Eventually, nonlinear regression techniques may allow consideration of the points raised here and in the Anderson and Wise study, and in fact some first steps in this direction are provided by the Anderson and Wise study. But currently the costs of carrying out such a study in depth are prohibitive.

This forces the choice of functional form to be approached from an empirical viewpoint. The main choice that has been found to be relevant in prior studies is between the linear form and the semi-logarithmic form. With the linear form the effect of one of the variables on price does not depend on the size of the other variables. This is the aspect sought for variables relating to the structure of the house in the Anderson and Wise theory. On the other hand, if it is felt that price is determined in the following form,

$$p_i = \alpha \exp\left(\sum_{j=1}^{n} \beta_j x_{ij}\right) e_i \qquad (3.17)$$

then the effects on price do vary as the other variables change. In order to make this equation amenable to regression analysis, it is necessary to take the natural logarithms of both sides yielding

$$\ln p_i = \alpha + \sum_{j=1}^{n} \beta_j x_{ij} + \varepsilon_i \qquad (3.18)$$

A choice between these two functional forms can be made empirically using the techniques developed by Box and Cox (1964) and discussed in Rao and Miller (1971). While one can choose between alternative definitions of independent variables by minimizing the residual sum of squares, this is not a legitimate technique here since the variance in price is influenced by the units selected while the variance of the natural logarithm of price is invariant to the choice of units of measurement of price. However, price can be transformed so that a comparison of the residual sums of squares is legitimate. This transformation is

$$p_i^* = c \cdot p_i \tag{3.19}$$

where

$$c = \exp\left(\frac{-\Sigma \ln p_i}{T}\right)$$

and T is number of observations. Then the two equations in the transformed variables,

$$p_i^* = \alpha_o^* + \sum_{j=1}^{n} \alpha_j^* x_{ij} + \varepsilon_{1j}^* \tag{3.20}$$

and

$$\ln(p_i^*) = \beta_o^* + \sum_{j=1}^{n} \beta_j^* x_{ij} + \varepsilon_{2i}^* \tag{3.21}$$

are estimated. The residual sums of squares are then minimized through selection of the functional form. It is important to discover if the difference in residual sums of squares is statistically significant. This test uses the statistic

$$d = \frac{T}{2}\left| \ln \frac{\Sigma e_{1i}^{*2}}{\Sigma e_{2i}^{*2}} \right| \tag{3.22}$$

where $\sum e_{1i}^{*2}$ and $\sum e_{2i}^{*2}$ are the residual sums of squares in the linear and semi-logarithmic equations respectively. This statistic is distributed chi-squared with one degree of freedom. The null hypothesis is that the forms are empirically equivalent.

Once the equation is correctly specified and estimated, it remains to interpret the results. Considerable controversy has been raised by the question of the correct interpretations of the coefficients of environmental variables derived from cross-sectional hedonic regressions. The study the effects of air pollution on property values by Ridker and Henning (1967) has served to raise these issues because of certain problems with the techniques they used. Their work was initially criticized by a number of researchers (Anderson and Crocker, 1972, Freeman, 1971, Polinsky and Shavell, 1975). Recently, works by Rosen (1974), Freeman (1974), Polinsky and Shavell (1976), and Polinsky, Shavell, and Rubinfeld (1974) have carefully formulated models which make clear the correct interpretations of the coefficients estimated previously. They have also developed new techniques that allow estimation of values that were previously incorrectly estimated solely from hedonic regressions. Many of these studies have been concerned with air pollution over entire urban area. This study is concerned with the more specific highway effects such as noise over a much smaller area, and this fact requires some modification of the work of others.

The following model is based on one developed by Polinsky, Shavell, and Rubinfeld (1974) with necessary modifications being made to adapt it to the current problem. It is a model of an urban area with land being used for (1) business use where a private consumption good is produced using land, labor, and capital; (2) residential use where housing services are produced by land and capital also according to constant-returns-to-scale production function; and (3) agricultural use which is a residual use setting a minimum price for land. It is assumed that the entrepreneurs and land owners are absentee economic agents. Residents work for the businesses, purchase the consumption good, and rent housing. Consumers work a fixed period of time and make a fixed number of work trips. The prices of the consumer good and capital are exogenous to any one city.

In the product market, equilibrium determines an implicit relationship between land prices in the business sector and the wage rate. These are the only two variables free to adjust to the zero profit condition dictated by constant returns-to-scale since product price and capital price are exogenous. In the land and labor markets equilibrium is determined by the usual conditions of equality of supply and demand which in turn are derived from the usual behavioral assumptions.

For our purposes it is assumed that there is perfect mobility both within the urban area and between urban areas. In this case, no individual could increase his level of utility by moving once equilibrium has been established through the adjustment land values and the wage rate. The wage rate can be taken as exogenous to residents of the small area bisected by a highway project, although it is endogenous to the city as a whole. The level of utility of the residents is influenced by, among other things, the level of amenities at the site of their residence. The amenity level depends on many things including the distance of the house from a highway.

The individual's utility is assumed to depend on the consumption of the private good, the consumption of housing, and an index of amenities at the residence. This utility is maximized subject to the individual's income. This process can be written explicitly as

$$\max_{x,q,h,k} U[x,q,a(h,k)] \text{ subject to } y = x+p[r(h,k),s]q+T(h,k) \qquad (3.23)$$

where

x=consumption of the private good (used as the numeraire with price set at unity),

q=consumption of housing,

a=the level of amenities,

h=distance of the residence from the highway

k=distance of the residence from the central business district

y=income,

p=rental price of housing services,

r=rental price of land,

s=price of capital,

t=transportation cost.

This direct utility function can be converted to an indirect utility function, V, relating the individual's utility level to prices and income:

$$V = V\{p[r(h,k),s],\ y - T(h,k), a(h,k)\} \qquad (3.24)$$

where $V_1 = \frac{\partial V}{\partial p} < 0$ and $V_2, V_3 > 0$. If the residents are identical with the same income, then they all reach a common level of utility, V*, which is determined exogenously when there is costless migration from other cities. Thus, if amenities improve in one location, then rents are bid up there until the common level of utility again prevails regardless of location. The change in the rent function when a new highway is constructed can be seen by differentiating V* with respect to h,

$$\frac{\partial V^*}{\partial h} = V_1 P_1 \frac{\partial r}{\partial h} - V_2 \frac{\partial T}{\partial h} + V_3 \frac{\partial a}{\partial h} = 0, \tag{3.25}$$

and solving for $\frac{\partial r}{\partial h}$,

$$\frac{\partial r}{\partial h} = \frac{V_2}{V_1 P_1} \frac{\partial T}{\partial h} - \frac{V_3}{V_1 P_1} \frac{\partial a}{\partial h} \tag{3.26}$$

A new highway would thus have two effects on rents: rents would tend to increase because of the reduction in travel costs, but they would tend to decrease if the proximity of highway had negative effects on amenities.

If the project being considered is a limited-access highway, then for a study area lying within a short distance of the highway the partial derivative of travel costs with respect to distance to the highway will be approximately zero in a cross-sectional study. The hedonic regression estimates the relationship between the capitalized value of future rents and the amenity schedule. If area affected is small enough relative to the urban area that there are no general equilibrium effects on wages or journey-to-work costs, then the estimated cross-sectional regression serves as an accurate predictor of the effects of amenity changes on property values in a small, open city where utility and income are constant.

If the population is composed of various classes with differing tastes and incomes, instead of the identical individuals previously postulated, this prediction becomes more complex. Polinsky, Shavell, and Rubinfeld (1974) are concerned with a change in air quality over the entire urban area. Here the estimates obtained serve only as a lower bound estimate since any time population classes change locations in the face of a change in amenities this implies that the previous occupants have been outbid. In this study a small study area is used for prediction of the effects on another small area when a highway bisects it. If the two areas are comparable in other respects, it is reasonable to assume that in the equilibrium after the new highway is opened similar population classes will occupy similar locations with respect to the highway. In this case, the relationship between property values and amenities determined in the first location is again a good predictor of the results in the second location.

The next question is whether or not the change in land values can serve as a measure of willingness to pay. Since the utility levels stay constant and businesses continue to fulfill the zero profit constraint, then the only actors who would be willing to pay to avoid the negative environmental effects would be landowners. They would be willing to pay up to the predicted change in land values to avoid the change in amenities.

It should be emphasized that this is a measure of total and not marginal willingness to pay. There are two types of questions in public finance: those concerning the efficiency of a particular policy and those concerning the distributional effects of the same policy. Direct use of hedonic regressions can help to answer important questions about the distributional effects. However, nothing can be said about efficiency questions without further analysis.

To proceed from this point, Polinsky and Shavell are forced to make strong assumptions about the form of the utility function. But such assumptions are backed by little empirical evidence, and it is preferable to be able to estimate the demand function for amenities directly. Rosen (1974) in an important work has laid the groundwork for proceeding in this direction.

Rosen goes beyond the usual hedonic equations to study the economic motives which lie behind the derived hedonic prices. The hedonic prices or rent gradients represent a series of equilibrium positions, and the derived coefficients cannot be interpreted as relating to the underlying demand curves. This is the source of the controversial shortcomings of the Ridker and Henning (1967) analysis.

Consider a particular type of commodity whose characteristics or attributes can vary between different models. These characteristics can be represented by a vector $z=(z_1,z_2,\ldots,z_n)$. Each model has a fixed vector of these characteristics, and the hedonic regression reveals the relationship between the price determined on the market for a model and the characteristics contained: $p(z)=p(z_1,z_2,\ldots,z_n)$.

If arbitrage and costless repackaging exists, then this function is necessarily linear. However, if repackaging is not costless, as with houses, then other functional forms are also theoretically valid. These prices are determined by the interaction of consumers demanding these products and the suppliers selling these commodities.

Consumers are assumed to maximize a strictly concave utility function $U=U(x,z_1,z_2,\ldots,z_n)$, by their choice of amounts of the composite commodity, x, and various characteristics, z_i, of the good being studied. They are constrained by their income, $y=x + p(z)$ where the price of x has been normalized at one. This constraint can be non-linear since p(z) is not necessarily linear. These two equations can be rewritten as a bid function $\theta(z_1,z_2,\ldots,z_n;u,y)$, which is defined implicitly by

$$U(y - \theta,z_1,\ldots,z_n) = u. \tag{3.27}$$

This bid function represents the amounts the consumer is willing to pay for different combinations of the characteristics with a given income and utility level. Concavity of θ in z is guaranteed by the assumed strict concavity of U. The consumer is willing to pay $\theta(z,u,y)$ for z at utility level u, and p(z) is the minimum price for z determined by the market. A consumer maximizes his utility by insuring that

$$\theta(z^*,u^*,y) = p(z^*) \tag{3.28}$$

and

$$\frac{\partial\theta}{\partial z_i} = \theta_{z_i}(z^*,u^*,y) = p_i(z^*) = \frac{\partial p}{\partial z_i} \tag{3.29}$$

where z^* is the optimum bundle of characteristics and u^* is the maximum utility level.

This can be seen graphically in Figure 3.1. In this figure the relationship between θ and the characteristic z_1 is shown when all other characteristics are at their optimum determined from equations 3.28 and 3.29. The bid functions for two individuals are shown. There are a large number of individuals with differing bid functions and differing incomes and tastes. The market insures that these bid functions are just tangent to the rent function p(z) for all individuals.

In the other half of the market the suppliers of these heterogeneous goods seek to maximize their profit, π, by selecting the design they will provide and the amount they will sell. If M(z) is the number of units of design z that the firm sells and C(M,z) represents the cost of producing the product, then the firm maximizes its profits $\pi = Mp(z) - C(M, z_1 z_2, \ldots, z_n)$. This function is converted to an offer function, $\phi(Z_1, Z_2, \ldots, Z_n, \pi)$, analagous to the bid function of consumers. This function, ϕ, is obtained by solving the equation

$$\pi = M\phi - C(M, z_1, z_2, \ldots, z_n) \tag{3.30}$$

for ϕ in terms of z and π. Thus for a particular level of profits, a firm will have offer prices for products with differing bundles of characteristics. The firm maximizes its profits by chosing the characteristics of its product so that

$$p_i(z^*) = \phi_{z_i}(Z_1^*, \ldots, Z_n^*, \pi^*) \tag{3.31}$$

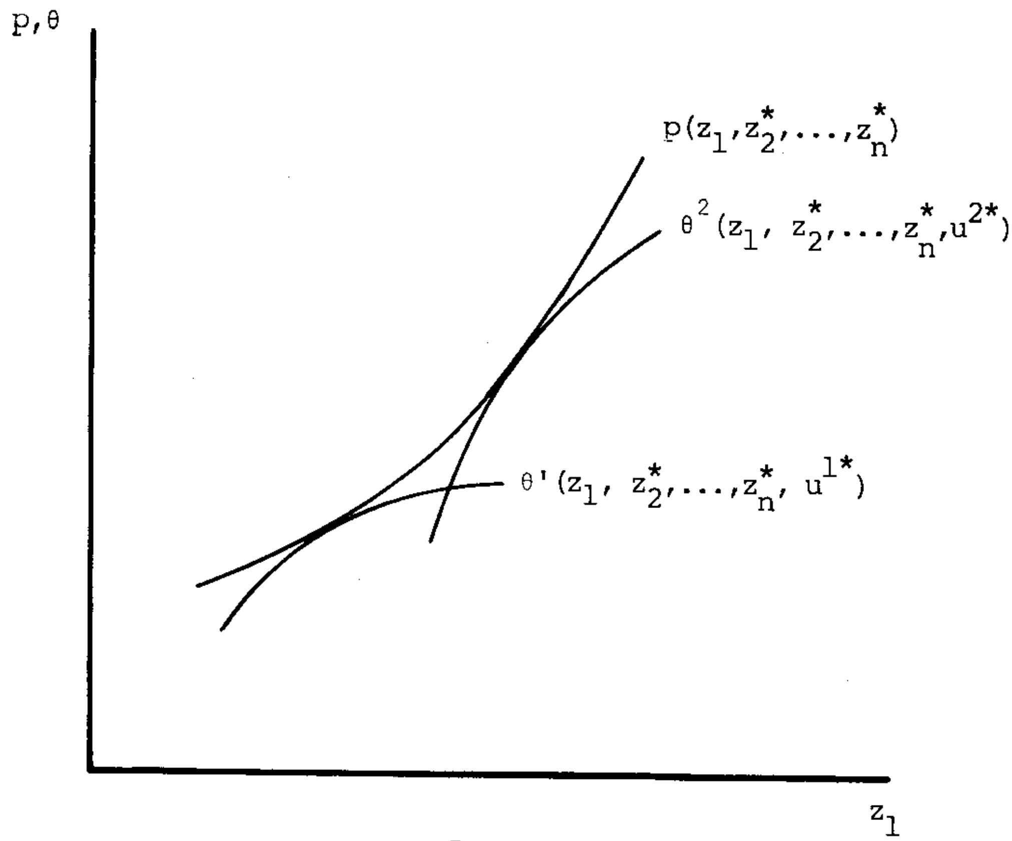


Figure 3.1

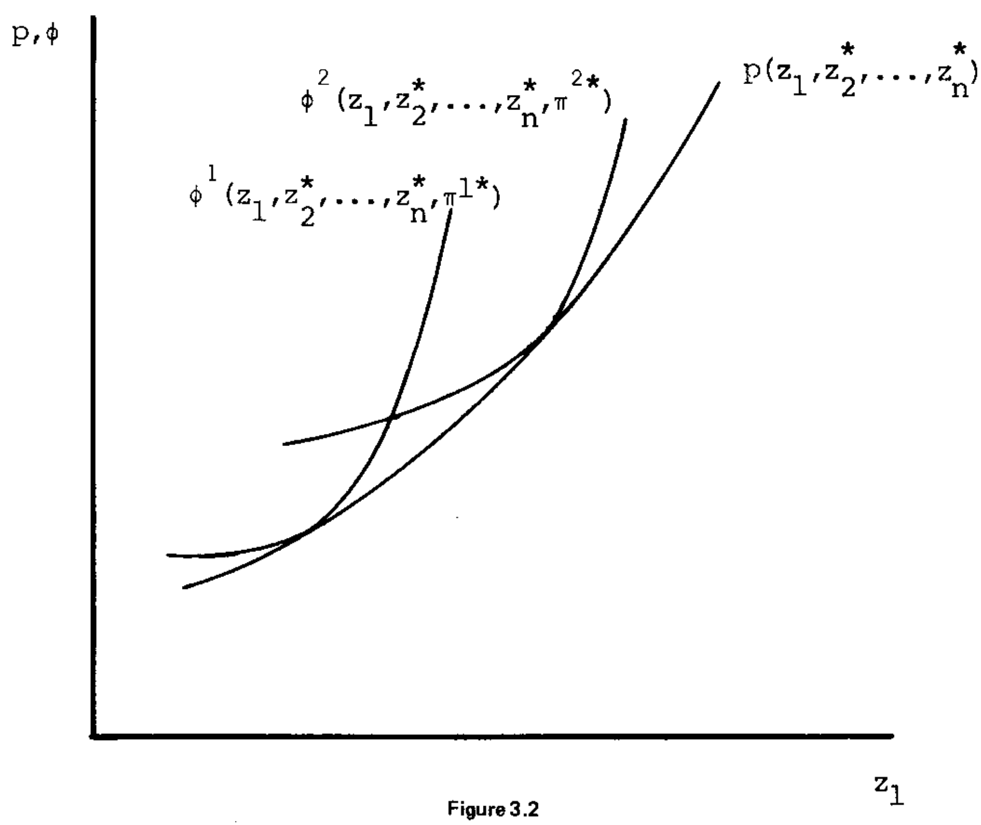


Figure 3.2

and

$$p(z^*) = \phi(z_1^*,\ldots,Z_n^*,\pi^*) \tag{3.32}$$

This can be seen graphically in Figure 3.2 where all characteristics other than z_1 have been chosen optimally. The offer functions of only two firms are shown. Different firms may face different costs if their technologies or factor prices differ or they possess a unique factor of production.

In equilibrium the price function p(z) is determined by the interaction of the consumer and supplier sides of the market. The bid and offer functions of the various economic actors will be tangent to each other and determine the equilibrium price gradient. This is shown graphically in Figure 3.3. Hedonic regressions estimate this price gradient and not the underlying supply and demand curves except in special cases. However, these demand and supply curves can be derived from the bid and offer surfaces. For example, the demand for a particular characteristic, z_1, can be obtained by differentiating the bid surface for an individual with respect to z_1. This represents the amounts the individual would be willing to pay for incremental amounts of z_1 at a constant utility level and are thus analogous to compensated demand functions. A similar procedure yields profit compensated supply curves by differentiating ϕ with respect to z_1. These functions are presented graphically in Fig. 3.4 when other characteristics and x are held constant.

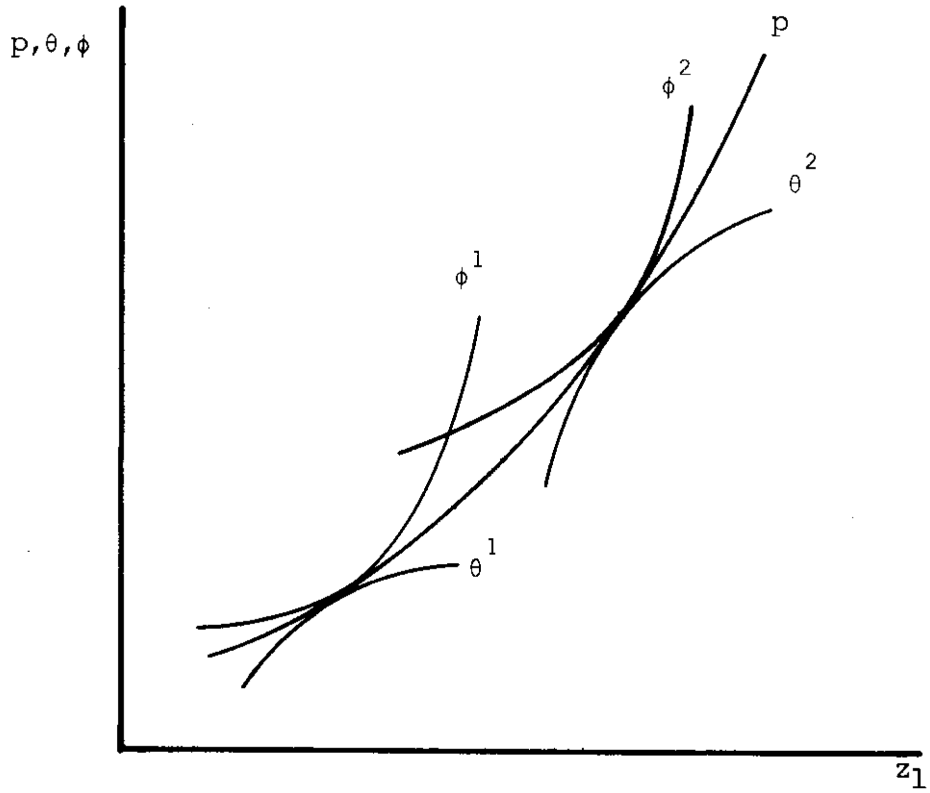


Figure 3.3

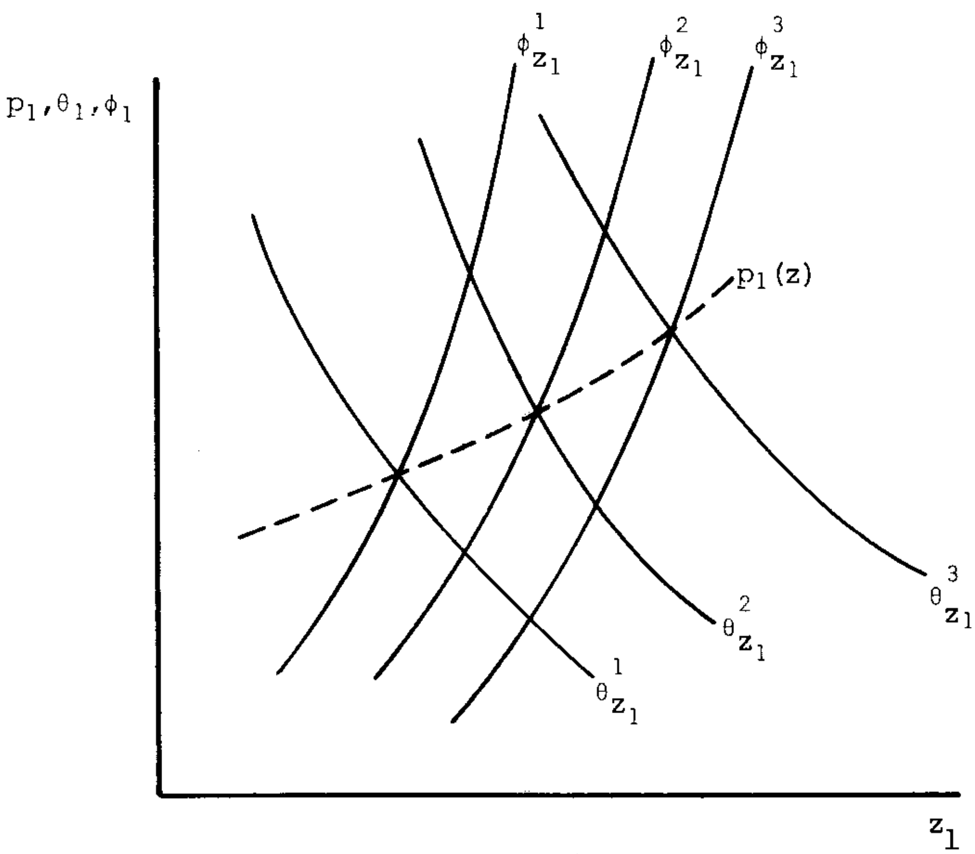


Figure 3.4

These curves can be estimated by a two-step procedure. First, a hedonic regression is used to estimate the function p(z), which is then differentiated with respect to z_1 to yield estimates of $p_i(z)$. These prices are combined with other variables influencing demand and supply, and the parameters of these curves are estimated. In general, there would be simultaneity bias present when ordinary least squares is used. A procedure such as two-stage least squares would be necessary. An exception to these statements would be when all firms face identical cost conditions, and the supply curve is thus traced out by the hedonic regression. A second exception would be when the consumers are identical, and the hedonic regression thus traces out the demand curve. This is the case in Polinsky, Shavell, and Rubinfeld (1974) when they assume that all consumers have identical Cobb-Douglas utility functions and identical incomes.

For this study certain modifications must be made in the analysis Rosen has developed. The main changes are on the supply side of the market. Instead of firms capable of producing output with various combinations of z, the real estate market is composed of houses with various locational characteristics which cannot be modified by the homeowner. Thus for a particular location there is a particular level of, for example, noise. Thus the offer function for that location has only one level of noise. In a figure analogous to Figure 3.3, the offer functions for a particular profit level are reduced to a vertical line at an amount of quiet Q equal to Q^* at prices above $p(z^*)$, the equilibrium price. At prices below $p(z^*)$ the landowner would not cover his opportunity costs and thus would sell the land rather than rent its services. The offer curve becomes horizontal at $p(z^*)$. Even at an infinite price more quiet than Q^* could not be offered. (For the moment the possibility of noise barriers, etc. is excluded.) Thus the associated supply curves become a series of perfectly inelastic schedules, as in Figure 3.5.

To this point it has been seen that only the hedonic regression is necessary to predict property value effects and total willingness to pay for abatement in comparable neighborhoods. To proceed beyond this point and consider marginal willingness to pay and the demand for pollution abatement, it is necessary to use the two-step procedure just discussed. Both these techniques answer important questions. Public finance is concerned with two issues in evaluating any project: Pareto efficiency and distributional effects. The first type of analysis is ideal for analyzing the distributional effects of a project, and from a poitical and legal standpoint this is often the most important issue. But economists and others are also concerned with the efficiency aspects of the project as well in order to evaluate the overall desirability of projects and policies. These questions require the second type of analysis.

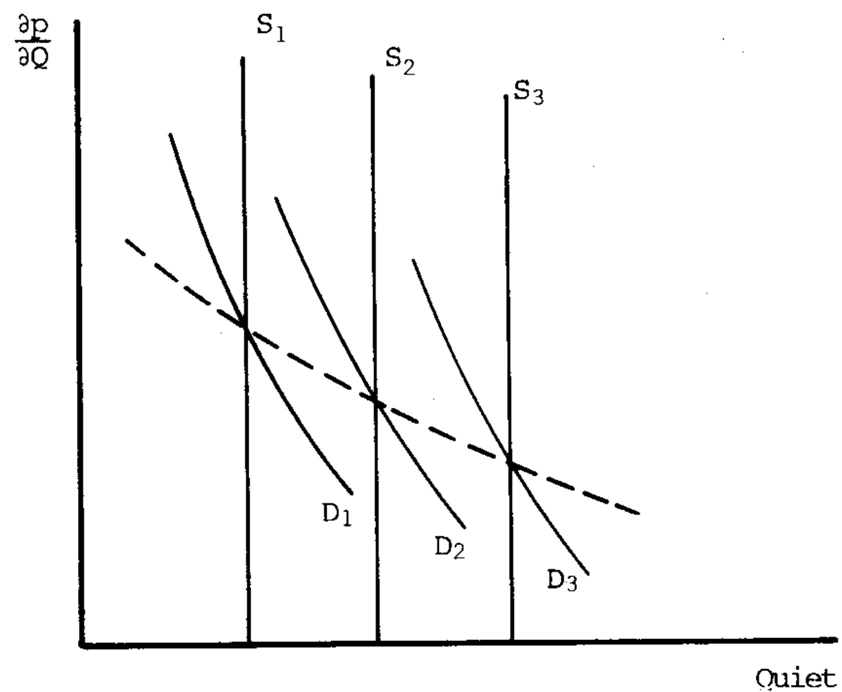


Figure 3.5

Chapter Four

Kingsgate Study Area

A number of criteria were used in selecting the study areas. An area having a large number of houses in close proximity to a limited access highway was considered essential for this study to enable assessment of any negative environmental effects. Also, it was desired that the houses be distributed so that they extended back from the highway about one mile. By utilizing such an area, some houses are adjacent to the highway while others are sufficiently removed that they do not experience any negative effects but do enjoy accessibility benefits. To increase the reliability of the hedonic regressions, the houses should be single-family dwellings and relatively homogeneous. The houses should not be influenced by non-highway negative environmental effects. The highway should have been opened fairly recently but should have been open long enough to allow property values to reach equilibrium. The study area should lie within a single political jurisdiction in order to avoid possible fiscal differences that may affect property values.

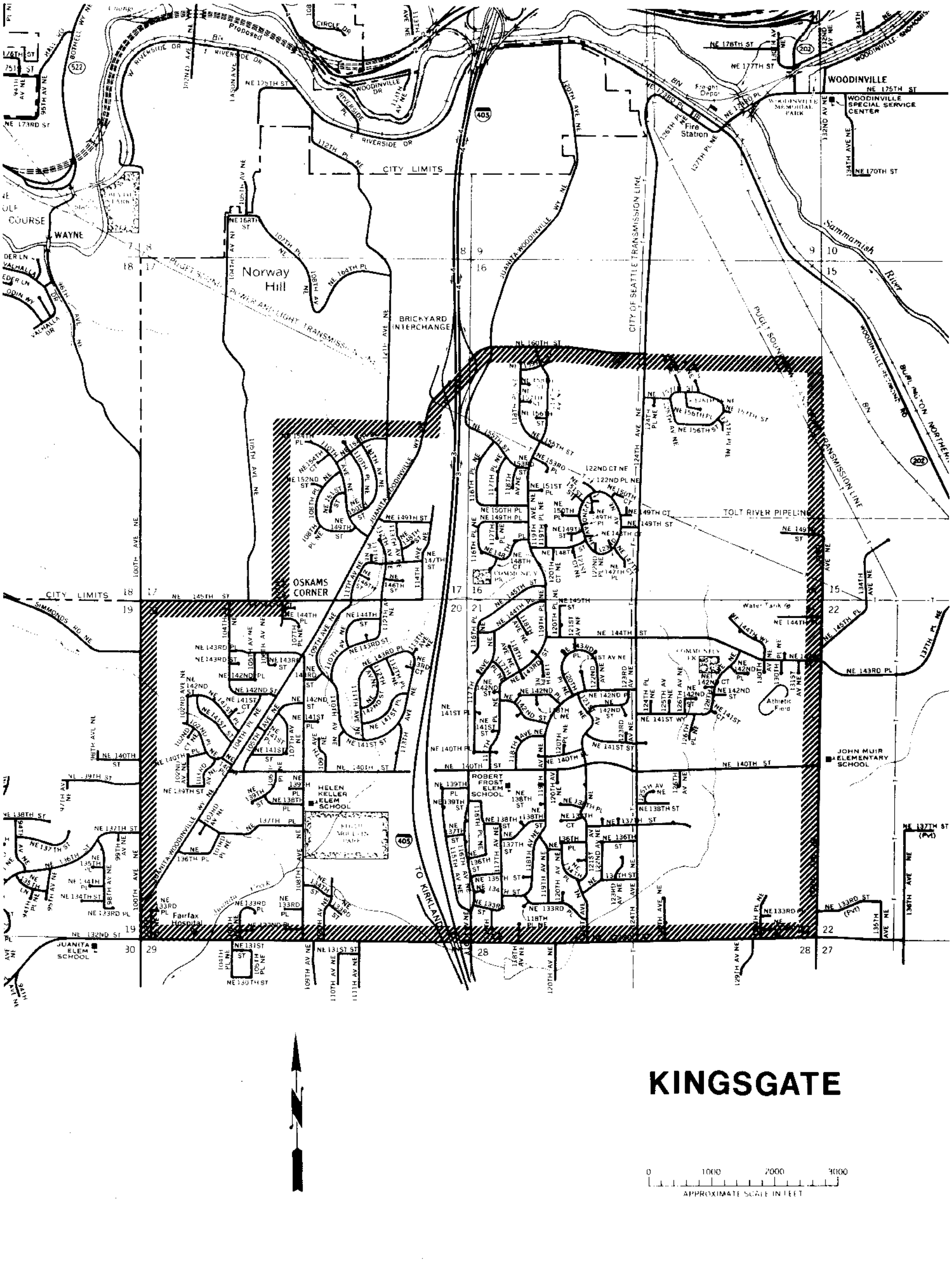
The first study area selected was in King County, on the east side of Lake Washington. This area, which is frequently referred to as the Kingsgate area, is located just north of the communities of Kirkland and Redmond and just south of Bothell. It is traversed by Interstate 405 with this section being opened to traffic toward the end of 1970. The study area is bounded by NE 160th Street and NE 132nd Street on the north and south and by 132nd Avenue NE and 100th

Avenue NE on the east and west. The direct distance of the houses from the nearest lane of traffic on I-405 ranges from a minimum of less than 100 feet to a maximum of 5,900 feet. There is an interchange at NE 160th Street, the north boundary of the study area, and at NE 124th Street, just south of the study area boundary. The minimum street distance of a house from the nearest interchange is 2,000 feet, while the maximum distance is 11,000 feet. The gently rolling terrain varies a little over 200 feet in elevation but with no undevelopable steep slopes. Some of the houses are completely exposed to the highway, while others are screened by stands of trees.

The area is predominantly occupied by single-family dwellings in the middle price range. The zoning laws prohibit more intensive use than single-family with only minor exceptions which were not included in the study. These exceptions include a few small commercial establishments and a limited area of multi-family dwellings. There remains some vacant land which is gradually being developed with single-family dwellings, but this also was excluded from the study. The oldest houses in the platted areas studied were built in 1962, while the major building expansion was begun in 1965.

Data Collection

The data were collected from various sources. The variables obtained are summarized in Table 4.1. The variables can be divided into groups by considering their source: 1) excise tax records 2) assessor's records, 3) direct measurement, and 4) published indexes.



WOODINVILLE
WOODINVILLE SPECIAL SERVICE CENTER
Fire Station
Norway Hill
BRICKYARD INTERCHANGE
OSKAMS CORNER
CITY LIMITS
CITY OF SEATTLE TRANSMISSION LINE
TOLT RIVER PIPELINE
PUGET SOUND POWER AND LIGHT TRANSMISSION LINE
Sammamish River
WAYNE
JUANITA-WOODINVILLE WY
ROBERT FROST ELEM SCHOOL
HELEN KELLER ELEM SCHOOL
JOHN MUIR ELEMENTARY SCHOOL
JUANITA ELEM SCHOOL
Fairfax Hospital
Athletic Field
TO KIRKLAND
NE 140TH ST
NE 145TH ST
NE 160TH ST
NE 132ND ST
NE 175TH ST
0 1000 2000 3000
APPROXIMATE SCALE IN FEET

KINGSGATE

The first group contains crucial information on prices and dates of sales. This information was obtained from the excise tax affidavits indicating the seller's payment of the one percent excise tax on all real estate transactions in Washington. This excise tax was established in 1951, so the affidavits were available for all relevant sales. The affidavits record not only the price and date of the sale, but also the type of deed involved and the parties to the sale. This information assisted in restricting the sales obtained to those that were representative of the value of the property. This was done by eliminating all sales where the conveyance was not either a warranty deed or a real estate contract. Sales between parties with the same last name were also eliminated. It was advantageous that this study area was in King County, since this is the only county where the excise tax affidavits are cross-indexed by location.

All valid sales between 1962 and July 1976 were obtained. This provided a data base of 4,785 sales for the analysis which follows. The sales prices varied from a minimum of $11,800 to a maximum of $57,000, but since there has been considerable inflation of real estate prices in the fifteen years being studied, it is necessary to deflate these figures to get the prices in constant dollars. Using the Seattle real estate market price index (1977), the prices were obtained in 1967 dollars. In this case the mean price was $23,012 with a range from $11,064 to $33,728.

The characteristics of the land and structures are included in the second grouping. These data were obtained from the King County

Table 4.1

	VARIABLE NAME	FORMAT	VARIABLE DESCRIPTIONS
	PLAT	F 2.0	Plat
	BLOCK	F 1.0	Block
	LOT	F 3.0	Lot
1	MULTSALE	F 1.0	Number of the sale for this property
	PRICE	F 5.0	Sale price
	MONTH	F 2.0	Sale date
	YEAR	F 2.0	
	CHARCHG	F 1.0	Change in characteristics between sales
	LOTWIDTH	F 3.0	Lot width
	USEWIDP	F 2.2	Useable lot width
	LOTDEPTH	F 3.0	Lot depth
	USEDEPP	F 2.2	Useable lot depth
	STRTACC	F 1.0	Street Access
	ALLEY	F 1.0	Alley
	CURBS	F 1.0	Curbs and gutters
	SEWER	F 1.0	Sewer
	WTRFRT	F 1.0	Waterfront
	VIEWTYPE	F 1.0	View type
	VIEWUTIL	F 1.0	View utilization
	UNDGNUTL	F 1.0	View utilization
	UNDGNUTL	F 1.0	Underground utilities
	REVIEW	F 1.0	Review
	RESTRICT	F 1.0	Restrictions
	EXTNUIS	F 1.0	External nuisances
	OBSOL	F 1.0	Obsolescence
	YRBUILT	F 2.0	Year built
	GRADE	F 2.1	Grade
	STORIES	F 2.1	Stories
	TOTRMS	F 2.0	Total Rooms
2	DINING	F 1.0	Dining room
	DEN	F 1.0	Den, family room, or recreation room
	BEDRMS	F 1.0	Bedrooms
	AREA1ST	F 4.0	First floor area
	AREA2ND	F 4.0	Second floor area
	UNFINFUL	F 4.0	Unfinished full story area
	FINATTIC	F 4.0	Finished attic area
	UNFINATT	F 4.0	Unfinished attic area
	FINHALF	F 4.0	Finished half-story area
	UNFHALF	F 4.0	Unfinished half-story area
	BASEAREA	F 4.0	Basement Area
	FINBASE	F 4.0	Finished basement area
	DAYLIGHT	F 1.0	Daylight basement
	EXTBRICK	F 3.0	Exterior brick - percent
	EXTSTONE	F 3.0	Exterior stone - percent
	BATHS	F 3.2	Bathrooms

(Continued)

Table 4.1 (cont'd)

	VARIABLE NAME	FORMAT	VARIABLE DESCRIPTIONS
	LAUNDRY	F 1.0	Laundry
	BUILTINS	F 2.0	No. of builtin appliances
	GARQUAL	F 1.0	Garage quality
	BSMTGAR	F 3.0	Basement garage area
	ATTGAR	F 3.0	Attached garage area
	DETGAR	F 3.0	Detached garage area
	DETGRADE	F 1.0	Detached garage grade
	DETYR	F 2.0	Detached garage construction year
	CARPORT	F 3.0	Carport area
	STALLS	F 1.0	Parking stalls
	HEATAREA	F 4.0	Heated area
	HTSOURCE	F 1.0	Heat source
	HTSYSTEM	F 1.0	Heat system
	FRPLSING	F 1.0	Single fireplace
	FRPLMULT	F 1.0	Multiple fireplace
2	FRPLFREE	F 1.0	Freestanding fireplace
	PORCH	F 3.0	Porch area
	DECK	F 3.0	Deck area
	FRPLOUTL	F 1.0	Other fireplace outlet
	POOLAREA	F 3.0	Pool area
	POOLQUAL	F 1.0	Pool quality
	CONCAREA	F 4.0	Concrete area
	ASPHAREA	F 4.0	Asphalt area
	EFFAGE	F 2.0	Effective age
	HWYDIST	F 2.0	Direct distance to highway (in 100 ft.)
	JWDIST	F 2.0	Direct distance to Juanita-Woodinville Rd. (in 100 ft.)
	INTCGDIS	F 2.0	Street distance to nearest interchange (in 1,000 ft.)
	SCHLDIST	F 2.0	Street distance to nearest elementary school (in 1,000 ft.)
3	PARKDIST	F 2.0	Street distance to nearest park (in 1,000 ft.)
	WESTHWY	F 1.0	West of the highway
	ABUTTING	F 1.0	Abutting the highway
	ELEV	F 3.0	Elevation with respect to highway
	NOISECON	F 1.0	Noise contour level
	NGHGROUP	F 1.0	Existence of neighborhood group (pool, dues, etc.)
	TREES1	F 1.0	House located in heavily treed area
	NTREES	F 1.0	Trees between house and highway
	CPI	F 4.3	Consumer price index
	MKIPRIND	F 3.2	Real estate price index
	CONSTIND	F 3.2	Construction price index
4	TOTEMLK	F 1.0	Totem Lake Shopping Center open
	EASTIND	F 3.2	Eastwide of Lake Washington index

Assessor's records. For each piece of property these records contain an extensive description of the lot and house. As explained earlier, a priori expectations dictate many of the variables to be collected here. These including the areas on the various floors, the year built, and the number of bathrooms. For others of the variables shown it was a question of whether or not they were relevant in this particular area. The empirical evidence was used to make this decision. The variables that were qualitative were made amenable to the regression analysis by transformation into dummy variables.

For sales that took place after 1971, the necessary records were readily available on microfiche. For property characteristics on sales prior to this time, it was necessary to consult the property record cards which were used until 1971. It was important to obtain the characterics in existence at the time of the sale rather than the characteristics currently in existence since there were cases where living space was added, unfinished space was finished, or plumbing was added after the initial construction.

A majority of the houses studied were single-story with only 7.3% of the houses being two-story and 1% being one-and-half story. Useable attic living space, either finished or unfinished, was present in 8.6% of the houses. Over 43% of the houses had basements, but only 15.3% had finished basements. Almost all of the houses had attached or basement garages, generally with two stalls. Those few without garages had carports. The mean of the first-floor areas was 1,327 square feet with a range from 620 to 2,890 square feet. Combining the finished areas on all floors yielded an average of 1,510 square feet, while unfinished living space averaged 447 square feet. The average house contained 1-3/4 baths and three built-in appliances. Sixty-five percent of the houses had been previously occupied at the time of the sale with the remainder being new. The average age at time of the sale was 2.2 years.

Data on the third group of variables were obtained directly. The most important variable concerned the noise levels at the various houses. Collection of this data required systematic noise monitoring. There are numerous measures of noise levels that have been developed. In this study it was important to use a measure that closely coincides with human perceptions of noise levels. First, it was desired to narrow the spectrum of frequencies to those most noticeable to the human ear. This was accomplished by using the A-weighted measure which emphasizes the higher frequencies. This measure of A-weighted decibels, dBA, is regarded as "statistically indistinguishable from the best psychological derived measures in its reliability as a predictor of human response to traffic noise. (C. Gordon, 1971)"

However, highway noise is not at a constant level but rather fluctuates continuously. Various methods have been developed which attempt to convert the fluctuating distribution of noise levels to a single, cardinal measure which best approximates human reaction to noise. The Environmental Protection Agency uses the measure of equivalent sound level, L_{eq}. This is the continuous, steady noise level that would contain the same noise energy as the time-varying noise in an equal period of time. This is one measure of the "average" noise level.

However, most studies of human reactions to noise indicate that the variations in noise levels are important as well as the average level (see Alexandre, et. al., 1975, Ch. 2 and the references cited therein). For this reason several indexes which take this variation into account have been developed. These measures are for the most part based on L_{10}, L_{50}, and L_{90}, the dBA levels that are exceeded 10, 50 and 90 percent of the time respectively. The two most common indexes are the Traffic Noise Index and the Noise Pollution Level index. The Traffic Noise Index derived in a study by Griffiths and Langdon (1968) takes account of these variations using L_{10} and L_{90} in the equation

$$TNI = L_{90} + 4(L_{10} - L_{90}) - 30.$$

An alternative is the Noise Pollution Level derived by Robinson (1971) in which

$$NPL = L_{50} + d + d^2/56$$

where $d = L_{10} - L_{90}$. Both these relationships were empirically derived and have not always proved robust (see Alexandre, et. al., 1975).

A series of studies summarized by Alexandre, et. al. (1975) have found the use of L_{eq} or L_{10} to be preferable to the alternative measures. In addition the Federal Highway Administration uses L_{10} in recommending design standards. For these reasons, L_{10} was selected as the measure of noise in this study.

The noise monitoring was carried out using the L_{10}-L_{50} Noise Measuring Instrument developed by the Applied Physics Laboratory at the University of Washington. This instrument provides L_{10} and L_{50} readings for given periods of time as well as instantaneous readings. The instrument automatically takes readings over a twenty minute period or a two minute period and reports the L_{10} and L_{50} for that period. During the monitoring period it also displays continuously the instantaneous noise level. The readings are supplied in 2½ dBA increments. The instrument is accurate within ± 0.1 dBA, although the calibration instrument is only accurate within ± 0.5 dBA.

Thirty noise monitoring stations were selected to provide a representative sampling for the area. Readings were taken at various distances from the highway, at different elevations with respect to the highway, and with varying vegetation covers. At least three readings were taken at each station during peak traffic hours. The mean of these readings was then recorded on assessor's maps. This information was then used to construct contour lines representing equal noise levels. This allowed the determination of the noise level within 2½ dBA at the center of each of the lots.

It might be questioned whether or not it was valid to apply noise readings taken in 1976 to earlier sales. To study this question traffic counts were obtained for the studied section of I-405 since it was opened. The peak hour traffic on weekdays varied from 2,482 vehicles/peak hour to 3,852 vehicles/peak hour over the time period studied. Galloway, et al. (1969) derived a system for predicting highway noise using such variables as traffic density. The formula they derived uses 10 log V as the contribution of traffic density to L_{50} where V is the number of vehicles per hour. The difference in the extreme traffic volumes accounts for just over two dBA difference. And at the same time that traffic volumes were increasing, speeds were decreasing due to the lowered speed limits imposed after the oil embargo. Speed enters the prediction formula as 30 log S. If speeds were fully reduced from 70 to 55 mph, this would reduce the L_{50} level by approximately 3 dBA. Thus two minor and approximately equal forces were changing in opposite directions since the highway opened. The noise readings were applied to all sales since the highway opened with few misgivings.

The various distances in the group three variables were determined from the assessor's maps. The distance to the highway was measured from the center of the lot to the nearest lane of traffic. Interchange distances were measured to the center of the overpass of the nearest interchange along the shortest street route. The other distances were similarly derived. The elevation with respect to the highway was derived from topographical maps and visits to the area. Information about the presence of trees between the house and the highway was also collected in visits to the area. Whether or not the house was in a plat that provided swimming pools and recreation facilities in return for mandatory dues was determined in the course of interviews with the homeowners. Over one-third of the houses were in such a neighborhood group.

The final group of variables represent temporal effects on prices. The consumer price index is derived by the Bureau of Labor Statistics to represent the trend in prices of all consumption goods for urban wage earners and clerical workers. The other price indexes are published by the Seattle Real Estate Research Committee and represent real estate price trends within the Seattle-Everett SMSA defined by the Bureau of the Census and also within the more limited area on the east side of Lake Washington. Finally, the date of the opening of the Totem Lake Shopping Center was included since many residents expressed the belief that this factor had influenced their property values.

Hedonic Price Index

The primary method of analysis used on the collected data involved hedonic regressions as described in Chapter Three. This technique requires selecting the variables that make a significant contribution to explaining the observed market prices. A number of these variables, such as the various floor areas and the age of the houses, were selected on theoretical grounds. The empirical work later substantiated these choices.

For other variables the choice was made empirically. For example, view property can have significantly greater value in many areas. But what had to be determined here was whether or not a view was an important explanatory variable in this study area. Only a very small number of houses were classed as having a view, and these only had a territorial view rather than a view of a specific object such as water or mountains. Experimental regressions revealed that the coefficient of view was not significantly different from zero, so this variable was not included. A variable such as the distance to the nearest park proved to be significant and so was included. While park distance is probably a factor considered by home purchasers, the coefficient of this variable most likely also serves as a proxy for the general environmental quality of the house location. The existence of a swimming pool serving certain plats obviously provides benefits to the residents, but it also entails costs in the form of dues to the house owners. In a long-run equilibrium these two factors would cancel out, and property values would not be affected by the existence of the pool. The significance of the coefficient of the neighborhood group variable is probably explained by the fact that the variable serves as a proxy for the quality of the houses in these plats as well as the absence of long-run equilibrium at the time of the study. The variable INOISE relates to the adverse highway effects and will be discussed subsequently.

The only important point for the current issues is that this variable represents the best specification of these effects. The variables D62 through D76 represent the year of the sale and are crucial to the current discussion.

The experiments leading to the particular form selected for the variables need to be discussed in some cases. The price that a house can command is partly affected by the age of the structure due to depreciation. Exponential depreciation is widely accepted in the economics literature. In this case the price equation becomes

$$p = \left(\sum_{i=1}^{n} \beta_i x_i\right) e^{\delta t} \qquad (4.1)$$

where t is the age of the structure and δ is a parameter that must be estimated. Unfortunately, current statistical techniques are not well equipped to estimate such an equation at a reasonable cost. However, again the Marshall and Swift (1977) appraisal handbook proved useful. Their depreciation tables are based on experience in the real estate market. For the range of ages considered in this study depreciation appears to be approximately a linear function of age. In fact a linear regression of their recommendations for depreciation with the age of the house yields an R^2 of .99096. Their experiences encourage the use of a simpler functional form.

Even if depreciation in percentage terms can be considered linear, this still necessitates consideration of the other variables since the depreciation in dollar terms of a large, five bedroom house is certainly different than that of a small two bedroom house. The same problem arises with the variable GRADE because the price difference of a quality increment is greater for a larger house. Such problems have been faced by Grether and Mieszkowski (1974) in their study of the "Determinants of Real Estate Values." In their study they weighted such variables by the square feet of living space. In this study a similar technique was tried with the weights being the sum of the finished floor space. In both cases the definition presented in the tables maximized R^2 when compared with the weighted forms. Also when living space was entered as a weight, the coefficients of previous living space variables became highly unstable. For these reasons the simpler forms of the variables were maintained. The variance of the size of the houses considered was not that great in this study, so simplification probably does not introduce much inaccuracy. For functional forms where the dependent variable is in logarithmic form this issue does not arise.

In Chapter Three it was noted that the use of time dummy variables with a linear functional form attributed the same absolute change in price to all houses regardless of value. In making the choice of functional form, this would bias the results in favor of the logarithmic forms if inflation was in percentage terms. To avoid this bias all nominal prices were deflated by the real estate market price index, MKTPRIND, as determined by the Seattle Real Estate Research Committee (1977).

Using RMPRICE, the real prices thus derived, and the independent variables selected as discussed previously, ordinary least squares regression yielded the results reported in Table 4.2. The estimated coefficients are in 1967 dollars, and coincide well with expectations and the Marshall and Swift (1977) appraisal recommendations discussed earlier. For every coefficient the hypothesis that the coefficient is equal to zero can be rejected with 95% confidence except in the case of three of the variables.

As explained earlier, theoretical arguments do not dictate the most appropriate functional form. An alternative form that has frequently proved useful in hedonic regressions is the semi-logarithmic case where the dependent variable is the natural logarithm of the real price, LRMPRICE. The results of such a regression are reported in Table 4.3. In a semi-logarithmic regression the coefficients of continuous variables represent the percentage change in price when that

Table 4.2

Hedonic Regression with RMPRICE as the Dependent Variable

VARIABLE[1]	COEFFICIENT	STD ERROR	T-STATISTIC
GRADE	1735.052	115.71259	14.994
AGE	-167.3936	13.87025	12.069
AREA1ST	5.401464	0.14703	36.736
AREA2ND	5.231323	0.11333	46.162
BSMTAREA	1.707604	0.12853	13.285
FINBASE	1.582082	0.18649	8.484
FINATTIC	1.304254	0.21478	6.073
UNFINATT	1.021029	0.20573	4.963
BATHS	1399.779	104.69841	13.370
BSMTGAR	2.628463	0.23725	11.079
ATTGAR	2.220860	0.26169	8.487
CONCAREA	0.4933946	0.10120	4.875
BUILTINS	174.5168	32.13538	5.431
PARKDIST	-20.49369	20.79096	0.986
WESTHWY	-450.6189	98.06174	4.595
NGHGROUP	482.2282	100.81204	4.783
FINHALF	4.954308	0.46429	10.671
DAYLIGHT	424.4685	103.94722	4.084
FRPL	482.2597	70.91146	6.801
TREES1	1218.257	115.40138	10.557
LOTAREA	0.1590082D-01	0.01582	1.005
D62	-1967.451	353.48298	5.566
D63	-1652.551	346.80092	4.765
D64	-1453.004	512.86319	2.833
D65	-1792.788	333.17292	5.381
D66	-2152.659	181.68584	11.848
D68	382.9127	163.98450	2.335
D69	-976.1320	165.02110	5.915
D70	-576.0522	175.38923	3.284
D71	-725.5687	183.40210	3.956
D72	-98.95340	183.99742	0.538
D73	1127.030	176.96681	6.369
D74	1376.242	180.54843	7.623
D75	2129.565	174.76741	12.185
D76	1452.663	182.35775	7.966
INOISE	-251.0814	76.56427	3.279
(CONSTANT)	-2982.334		

R SQUARE	0.80062
ADJUSTED R SQUARE	0.79911
STANDARD ERROR	2107.84878

[1]Variables not previously defined:
AGE = YEAR-YRBUILT
BSMTAREA = BASEAREA-BSMTGAR
FRPL = FRPLSING+FRPLMULT+FRPLFREE
LOTAREA = LOTWIDTH ' LOTDEPTH
INOISE = NOISECON if YR GE 1971

Table 4.3

Hedonic Regression with LRMPRICE as the Dependent Variable

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTIC	COEFFICIENT EVALUATED AT MEAN PRICE
GRADE	0.6574821D-01	0.00449	14.659	1513.007
AGE	-0.7876373D-02	0.00054	14.650	-181.252
AREA1ST	0.2320804D-03	0.00001	40.721	5.341
AREA2ND	0.1921580D-03	0.00000	43.745	4.422
BSMTAREA	0.7671618D-04	0.00000	15.398	1.765
FINBASE	0.5534537D-04	0.00001	7.656	1.274
FINATTIC	0.4912798D-04	0.00001	5.901	1.131
UNFINATT	0.4126381D-04	0.00001	5.174	0.950
BATHS	0.7083930D-01	0.00406	17.455	1630.164
BSMTGAR	0.1245857D-03	0.00001	13.548	2.867
ATTGAR	0.1143966D-03	0.00001	11.278	2.632
CONCAREA	0.1978254D-04	0.00000	5.043	0.455
BUILTINS	0.1272336D-01	0.00125	10.214	292.792
PARKDIST	-0.1196191D-02	0.00081	1.484	-27.527
WESTHWY	-0.2160117D-01	0.00380	5.683	-491.759
NGHGROUP	0.2542814D-01	0.00391	6.507	592.659
FINHALF	0.1912349D-03	0.00002	10.626	4.401
DAYLIGHT	0.2005895D-01	0.00403	4.978	466.260
FRPL	0.2402829D-01	0.00275	8.742	552.942
TREES1	0.4209100D-01	0.00447	9.410	989.279
LOTAREA	0.4950893D-06	0.00000	0.807	0.011
D62	-0.1145158	0.01370	8.358	
D63	-0.9018844D-01	0.01344	6.709	
D64	-0.7527160D-01	0.01988	3.786	
D65	-0.9826009D-01	0.01291	7.609	
D66	-0.9228270D-01	0.00704	13.104	
D68	0.1629307D-01	0.00636	2.563	
D69	-0.4712371D-01	0.00640	7.367	
D70	-0.2783536D-01	0.00680	4.094	
D71	-0.3450362D-01	0.00711	4.854	
D72	-0.4235396D-02	0.00713	0.594	
D73	0.4651290D-01	0.00686	6.781	
D74	0.5866239D-01	0.00700	8.382	
D75	0.9344940D-01	0.00677	13.795	
D76	0.6740691D-01	0.00707	9.536	
INOISE	-0.1067901D-01	0.00297	3.598	-245.747
(CONSTANT)	8.933155			

R SQUARE	0.83537
ADJUSTED R SQUARE	0.83412
STANDARD ERROR	0.08170

attribute is changed. To assist in comparison with the previous regression, the coefficients have also been evaluated at the mean price. It can be seen that the values still accord with expectations and appraisal techniques, although naturally they differ slightly from the linear coefficients.

The choice between the two functional forms is empirical. As explained previously, a transformation of the dependent variables is necessary before the residual sums of squares can be compared. In order to standardize the linear and semi-logarithmic forms, it is necessary to multiply RMPRICE by the inverse of the geometric mean of RMPRICE. When the two equations with the transformed variables were run, the residual sums of squares were 41.796 for the linear case and 32.283 for the semi-logarithmic case. Thus the semi-logarithmic form appears preferable. The test described above was applied to see if this difference was statistically significant. The calculated value of the test statistic was 617.93 with one degree of freedom. This far exceeds the critical value at a 99% confidence level, so one can safely reject the hypothesis that the functions are empirically equal. The Box-Cox test also caused the rejection of the inverse semilogarithmic form. While the log-linear form performed slightly better than the semi-logarithmic form, the difference was not statistically significant at the .01 level. Some of the coefficients were implausible in the log-linear case. The semi-logarithmic form is thus used in the following discussion. For this form it is appropriate to use nominal prices, and these results are reported in Table 4.4.

The dummy variables D62 through D76 provide one means of deriving indexes using the results of the regression reported in Table 4.4. However, the accuracy of this index depends on whether or not aggregating sales over years was a justified procedure. The Chow test can be used to test the hypothesis that such aggregation was reasonable. To do this, separate regressions were run on each year's sales using the previously discussed specification with the exception of the time dummy variables. The calculated Chow test statistic is 2.41 with 231 and 4,409 degrees of freedom in the numerator and denominator respectively. This far exceeds the tabled F value, and thus the hypothesis is rejected that the aggregated regression represents a valid restriction. The different components of housing costs have increased differentially in the fifteen years studied, so it is not surprising that the hedonic prices of the various attributes have also changed.

How serious a problem is this as far as the estimation of the coefficients of the time dummy variables? The equivalent of the yearly regressions can be accomplished through a saturated analysis of covariance model where new variables are created by multiplying the time dummy variables by the attribute variables. When viewed from this standpoint, the aggregated regression represents a case of left-out variables. When there are left-out variables, the estimates of the coefficients of the remaining variables are biased. The amount of bias depends on the true coefficients of the left-out variables and the coefficients of the included variables when they are regressed on the left-out variables as dependent variables. The Chow test indicates that the coefficients of the left-out variables are signifi-

TABLE 4.4

HEDONIC REGRESSIONS WITH LPRICE AS THE DEPENDENT VARIABLE AND MEASURED NOISE LEVELS

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTIC	COEFFICIENT EVALUATED AT MEAN PRICE
GRADE	0.6629537×10^{-1}	0.00455	14.579	1854.126
AGE	$-0.7939683 \times 10^{-2}$	0.00055	14.566	- 222.054
AREA1ST	0.2311599×10^{-3}	0.00001	40.005	6.465
AREA2ND	0.1922979×10^{-3}	0.00000	43.178	5.378
FINHALF	0.1926129×10^{-3}	0.00002	10.556	5.387
BSMTAREA	0.7653529×10^{-4}	0.00001	15.152	2.141
FINBASE	0.5544335×10^{-4}	0.00001	7.565	1.551
DAYLIGHT	0.2074034×10^{-1}	0.00409	5.077	586.116
FINATTIC	0.4896862×10^{-4}	0.00001	5.802	1.370
UNFINATT	0.4211678×10^{-4}	0.00001	5.209	1.178
BATHS	0.7056662×10^{-1}	0.00411	17.151	1973.583
BSMTGAR	0.1245557×10^{-3}	0.00001	13.359	3.484
ATTGAR	0.1146876×10^{-3}	0.00001	11.152	3.208
CONCAREA	0.2027710×10^{-4}	0.00000	5.098	.567
BUILTINS	0.1300759×10^{-1}	0.00126	10.300	363.792
FRPL	0.2364046×10^{-1}	0.00279	8.483	661.168
PARKDIST	$-0.1603184 \times 10^{-2}$	0.00082	1.962	- 44.837
WESTHWY	$-0.2124004 \times 10^{-1}$	0.00385	5.512	- 587.770
NGHGROUP	0.2436604×10^{-1}	0.00396	6.150	689.831
LOTAREA	0.3969244×10^{-6}	0.00000	.639	.011
TREES1	0.4149971×10^{-1}	0.00454	9.151	1185.070
D62	-0.1930821	0.01389	13.899	
D63	-0.1647059	0.01363	12.085	
D64	-0.1457969	0.02015	7.234	
D65	-0.1587203	0.01309	12.122	
D66	-0.1276447	0.00714	17.877	
D68	0.6035037×10^{-1}	0.00644	9.365	
D69	0.1128443	0.00649	17.400	
D70	0.1138938	0.00689	16.524	
D71	0.1080181	0.00721	14.987	
D72	0.1609392	0.00723	22.257	
D73	0.2457777	0.00695	35.340	
D74	0.3295876	0.00710	46.451	
D75	0.4386603	0.00687	63.869	
D76	0.5039635	0.00717	70.322	
INOISE	$-0.1189996 \times 10^{-1}$	0.00301	3.955	- 332.814
(CONSTANT)	8.934197			

R-SQUARE	0.90098
ADJUSTED R-SQUARE ($\bar{R}^2$)	0.90023
STANDARD ERROR	0.08284

cant. It is also to be expected that the time dummy variables will be correlated with the variables created to allow for time variation in the other variable coefficients. Thus disaggregation is indicated. The test proposed by Box and Cox (1964) was again used to see which functional form was preferable. With the exception of only one of the fifteen years, the semi-logarithmic form was again superior.

The Chow test points to disaggregation by years. However, in order to develop the price indexes sought, regressions on pairs of years were necessary. Chow tests indicated that in general such aggregation was acceptable. This allows the creation of the chain hedonic indexes described earlier. This index is reported in Table 4.5, along with the index derived from the aggregate hedonic regression. All indexes are normalized on 1971 to coincide with the opening of I-405. In the disaggregated regressions a number of the characteristics did not apply to any of the houses that sold before 1965. For this reason the indexes were begun in 1965 in these cases. Because the data stopped in July of 1976, the indexes generated for this year were not representative of the full year.

Resale Price Index

The data collected for this study contained repeat sales for many of the houses. In fact, there were 1,021 houses with two sales, 291 with three sales, 57 with four, and 11 with five sales. This provided an excellent opportunity to check the specification of the equation used in the hedonic regressions by generating the price index by the

TABLE 4.5

Year	Index from Aggregated Hedonic Regression on LPRICE	Index from Chain Hedonic Regressions on LPRICE
62	.740	
63	.761	
64	.776	
65	.766	.777
66	.790	.801
67	.898	.905
68	.953	.960
69	1.004	1.008
70	1.006	1.007
71	1.000	1.000
72	1.055	1.049
73	1.148	1.140
74	1.248	1.239
75	1.392	1.383
76	1.486	1.479

alternative technique developed by Bailey, Muth, and Nourse (1963). The techniques in this procedure are discussed in Chapter III. All sales pairs were included in the study. The hedonic data allowed distinguishing between repeat sales where the characteristics of the house remained the same and those where there was remodeling or enlarging. Thus it was possible to test whether or not knowledge of the characteristics of the houses was necessary to reliably apply this technique. If this was not necessary, considerable savings could be realized in some studies by omitting these data.

The sales pairs were separated into two groups according to the relationship of the house to the highway. The noise monitoring and hedonic study indicated that any adverse proximity effects occured in houses within 600 feet of the highway. Thus, those sales pairs for property within 600 feet of the highway were categorized as being in the impact group. Sales pairs for properties further back were considered to be in the study group. For repeat sales where the characteristics did not change, there were 1,473 sales pairs in the study area and 140 sales pairs in the impact area. Admitting sales pairs where there had been an intervening characteristics change added 160 cases to the study area and 38 cases to the impact area.

The price relatives were adjusted for depreciation as described above. An example of the regressions that were run is provided in Table 4.6. The variable YR67 was not included in order to normalize the index on the year 1967. This regression is for the study area with constant characteristics. A similar regression was run for the impact area. The anti-log of the coefficients was then found, and the

Table 4.6

MULTIPLE SALE REGRESSION WITH HEDONIC DEPRECIATION ESTIMATE

Variable	Coefficient	Standard Error	Index	95% Confidence Interval Low	High
YR62	-0.217	0.016	.8049	.7804	.8303
YR63	-0.209	0.018	.8114	.7835	.8403
YR64	-0.145	0.021	.8650	.8303	.9012
YR65	-0.155	0.016	.8564	.8303	.8834
YR66	-0.091	0.010	.9130	.8949	.9315
YR67	-	-	1.0000	-	-
YR68	0.053	0.009	1.0544	1.0356	1.0736
YR69	0.121	0.008	1.1286	1.1107	1.1468
YR70	0.106	0.009	1.1118	1.0920	1.1320
YR71	0.096	0.009	1.1008	1.0811	1.1208
YR72	0.148	0.009	1.1595	1.1388	1.1806
YR73	0.217	0.009	1.2423	1.2202	1.2649
YR74	0.304	0.010	1.3553	1.3284	1.3854
YR75	0.409	0.011	1.5053	1.4726	1.5388
YR76	0.495	0.011	1.6405	1.6048	1.6770

R-SQUARE 0.6976
ADJUSTED R-SQUARE ($\bar{R}$) 0.6951
STANDARD ERROR 0.0023

TABLE 4.7

YEAR	STUDY AREA INDEX	IMPACT AREA INDEX
62	.731	
63	.737	
64	.786	
65	.778	.743
66	.829	.773
67	.908	.921
68	.958	.954
69	1.025	.964
70	1.010	.970
71	1.000	1.000
72	1.053	1.065
73	1.129	1.146
74	1.231	1.167
75	1.367	1.255
76	1.490	1.381

resulting indexes were normalized in 1971 for comparison with the hedonic results. The indexes for the two areas are reported in Table 4.7. There were no houses within the impact area until 1965.

Comparison of the two indexes shows that since the highway opened houses in the impact area have appreciated at a slightly slower rate than those in the study area. This coincides with the more detailed results concerning adverse proximity effects which are described later in this report. A Chow test substantiates this difference with a test statistic of 3.14 with 14 and 1585 degrees of freedom in the numerator and denominator respectively and a tabled value of 2.08 with 99% confidence. Thus, the legitimacy of aggregating the two areas was rejected.

Next the data were examined to see if the remodeling and adding space had a significant effect on the indexes derived. The two groups within the study area were analyzed separately and then aggregated together. The Chow test statistic was 4.453 with 14 and 1,605 degrees of freedom in the numerator and denominator respectively. The F-table has a critical value of 2.09 with 99% confidence for these degrees of freedom. The hypothesis that characteristic changes can be ignored is rejected. In this study approximately ten percent of the sales pairs had characteristic change between sales. The index values were increased slightly less than one percent when such sales pairs were added.

In a study such as this one where the houses are quite new, the number of houses with such changes may be small enough so that such changes can be ignored if cost savings are important. The index will be biased upward but by a small amount. However, in studies involving older houses the changes may be more frequent and major. In such cases the bias might be substantial.

For the above reasons the index for the study area with no characteristic changes was the most reliable. It was used for testing the accuracy of the chain hedonic index using LPRICE as the dependent variable. The standard errors of the regression coefficients were used to establish 95% confidence intervals in the logarithmic form used in the regressions. These confidence intervals were then converted to the form used for the indexes. These results are also contained in table 4.6.

A close correspondence exists between the resale and chain hedonic indexes. A test of the equivalence of the indexes in a particular year could be made if the variance as well as the mean of the two estimates were known. Unfortunately, the chain hedonic index is derived by combining multiplicatively the estimates from the yearly pairs. When estimates from two populations of known variance are multiplied together, the variance of combined estimate cannot be reasonably calculated. Thus, the usual T-test, or approximation thereof, cannot be made. The best alternative was testing for each year the hypothesis that the true value of the multiple sale index was equal to the chain index. For every year since the highway was opened the hypothesis that the indexes were equal could not be rejected. In only one of the years before the highway was opened could the hypothesis be rejected. The fact that the hedonic index agrees so closely with the non-hedonic multiple sale index provides additional support for the specification of the hedonic equation. Thus Griliches' expressed misgivings about hedonic indexes do not seem to be a problem in the current study.

Highway Accessibility and Property Values

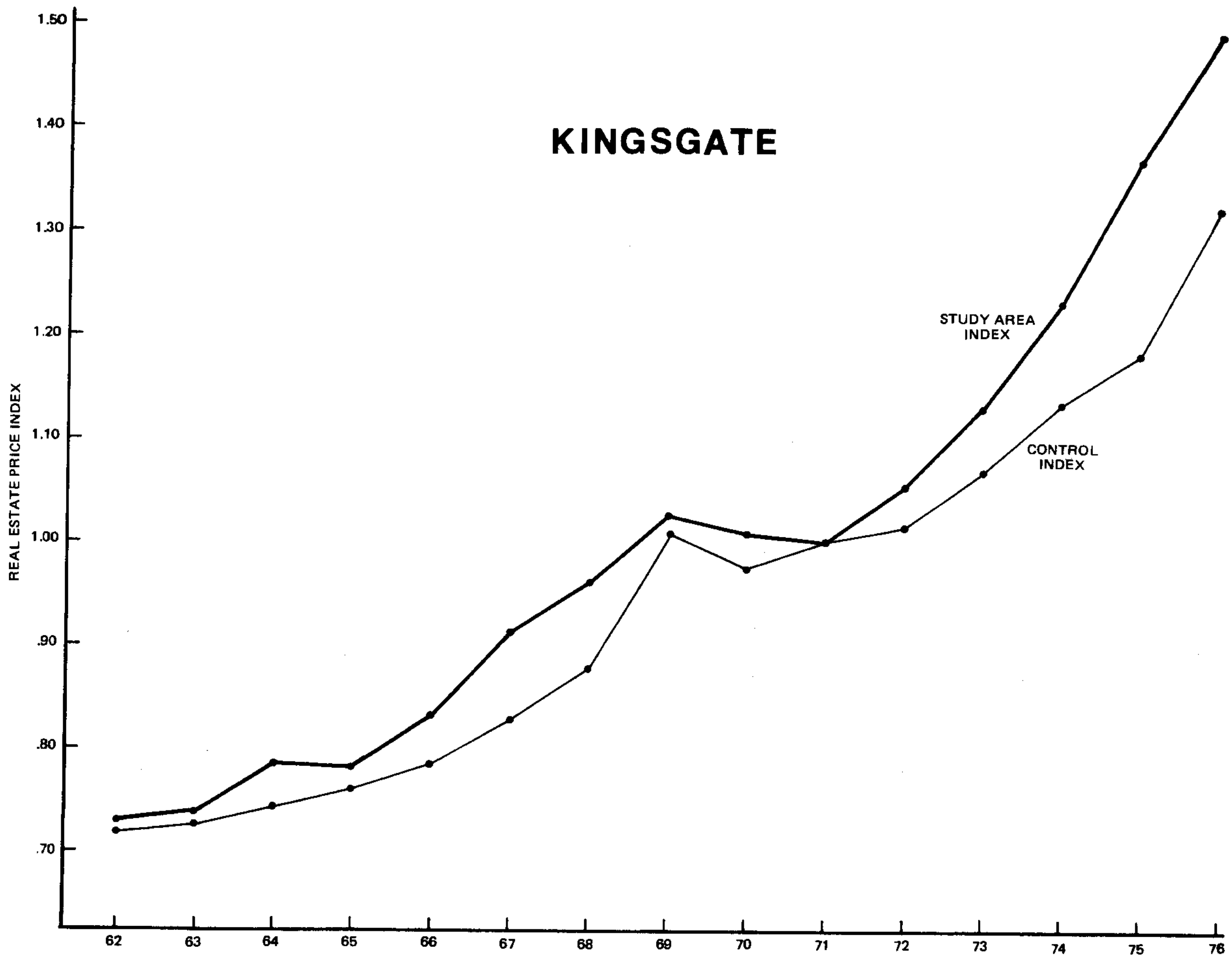
To assess the impact of the highway upon property values, it was necessary to know the general trend in real estate price during these years. The Seattle Real Estate Research Committee computes price indexes for single-family residential properties in various areas. The index for properties on the eastside of Lake Washington was considered to be most comparable. Properties in this area were approximately the same distance from Seattle and the same age as those in the study area. Only a small fraction of the houses on the eastside were affected by major highway changes during that time. This eastside index is reported in Table 4.8.

After the opening of I-405, the affected properties appreciated in value at a considerably faster pace than average properties on the eastside of Lake Washington. Between the opening of the highway and 1975, the houses in the study area appreciated an average of 12 percent more than houses elsewhere on the eastside. These results are presented graphically in Figure 4.1. In 1976 the average sales price of houses in the study area was $36,787. Applying the indexes to this mean value shows that average house was worth $4,414 more than if it were located away from access to a major highway. The full effect of the highway did not seem to take place immediately but rather property

TABLE 4.8

Comparison of Kingsgate Index and Eastside Index

Year	Kingsgate Study Area Resale Index	Eastside Index
62	.731	.719
63	.737	.727
64	.786	.743
65	.778	.760
66	.829	.785
67	.908	.826
68	.958	.876
69	1.025	1.008
70	1.010	.975
71	1.000	1.000
72	1.053	1.016
73	1.129	1.066
74	1.231	1.132
75	1.367	1.181
76	1.490	1.322


KINGSGATE
REAL ESTATE PRICE INDEX
1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
STUDY AREA INDEX
CONTROL INDEX
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
YEAR
Figure 4.1

values increased over several years. Also, property value increases may not have anticipated the opening of the highway. These last two facts seem to contradict the effects predicted in a model with perfect markets, since the location of a new highway is well publicized far before it is opened. However, the necessary perfect markets may not actually exist, and various frictions could account for the results observed where the appreciation appears with a lag. It should be noted, though, that the index for the study area also diverged from the control index in the late sixties. It is possible that this was due to the anticipated highway construction, or it may be due to some outside difference in the two indexes. If it was due to the highway, then the great instability in the Seattle area around 1970 due to the reduction in employment in aerospace industry may account for the reduction in the differences between the two indexes during those years.

Adverse Impacts on Property Values

The analysis so far has been concerned with the beneficial effects of a highway on surrounding neighborhoods. Unfortunately, a major highway may also inflict adverse effects on nearby property owners. These effects may take the form of noise, air pollution, vibration, lights, visual effects, or neighborhood segmentation. In the study by Gamble, et al. (1973), they monitored both noise and air pollution. When the data were analyzed, it was found that when both the noise and the air pollution readings were included in the regressions the estimates became unstable. This was due to the multicollinearity in the two variables. They were forced to include only noise, using it as a proxy for various adverse effects. The same procedure was followed in this study. However, when subsequent interviewing of the residents of the affected houses was done, more than 90 percent of those individuals that perceived any adverse effects felt that noise was the worst problem and only about 10 percent felt there was any problem other than noise. Thus, the noise variable is probably predominantly measuring the noise effect rather than serving as a proxy for all adverse effects. Because of the rolling terrain everywhere and the presence of evergreen trees in some locations, very few of the houses had a direct view of the highway from inside the house. This probably accounts for the fact that few residents mentioned visual effects. However, note the comments later in this chapter when a variable representing the noise mitigating affects of trees is included.

As explained earlier, noise monitoring was done at thirty locations where highway noise was a factor in the noise environment. These readings on L_{10} and L_{50} were then used to construct contour lines of equal dBA levels during peak hours. These contour lines allowed estimating the noise levels at each house within the study area.

The form with which this variable affects housing prices had to be determined since individuals' annoyance may increase more than proportionally when the dBA level increases. To allow for such behavior, the noise variable was entered in several alternative forms, and the selection was made empirically. Each 2½ dBA interval above 55 dBA was assigned a zone number. The variable INOISE was used to allow the noise damages to be a linear function of the L_{10} readings above 55 dBA. The square of the zone number was used to form INOISQ where damages increased more than proportionally when noise increased. The natural antilog of the zone numbers yielded ENOIS which represented even more curvature. Finally, the zones were combined in pairs with dummy variables assigned to each of the pairs. This allowed alternative non-linearities to be introduced. The variable was selected which maximized $\bar{R}^2$ and thus the explanatory power of the equation.

The variable INOISE proved to be the best definition. A close alternative was provided by the dummy variables IN1 through IN3, but the introduction of two extra variables reduced the number of degrees of freedom and did not add to the explanatory power. Thus, $\bar{R}^2$ dropped when these varibles were added. The other definitions were less successful at explaining the variance in prices. Thus INOISE was selected as most representative of people's reaction to noise when purchasing houses. The value of damages for various dBA levels under the alternative definitions is listed in Table 4.9 and the results with the variable selected are detailed in Table 4.10.

When developing the price indexes, a Chow test revealed that combining all the years was an unjustified aggregation. The same problems might exist here, so yearly regressions using INOISE were run. The coefficients all had the expected sign, but naturally the precision of the estimates was reduced. Because of this the latest estimate was over twice as large as the smallest estimate of damages. The variations in the estimates followed no discernable pattern and certainly could not be associated with the growth in the traffic on

I-405. The increase in the standard errors of the estimates made it impossible in several cases to reject the hypothesis that the coefficients were equal to zero.

These problems of lack of precision were avoided when the data were aggregated as reported above. Could such action be justified in this case? The Chow test uses separate regressions for each of the years, but the same results could be obtained using a saturated analysis of covariance model. In this case dummy variables would be used to allow the variables to have different coefficient values in each of the yers. The Chow test has revealed that the results in such a saturated model are superior to the results from the aggregated regression without these dummy variables. For this reason the aggregated regression can be considered to be a case of left-out variables where the omitted variables are the dummies.

TABLE 4.9

Estimated Noise Damages to the Average House (in 1967 dollars) with Various Variable Forms 1/

dBA L_{10}	Zone #	INOISE	INOISQ	ENOIS	IN1-IN3
		Noise Variable Form			
55					
	1	333	76	23	366
57.5					
	2	666	306	61	733
60.0					
	3	998	688	167	824
62.5					
	4	1,331	1,223	454	1099
65					
	5	1,664	1,911	1,233	1618
67.5					
	6	1,997	2,752	3,353	1957

1/The hedonic regressions involving these various variable forms have the form $\ln p = -\gamma f(N) + \sum \beta_i X_i$ where N is the measured noise level and the X_i are the other characteristics, so $\partial p/\partial N = -\gamma p f'(N)$. The integral of $\partial p/\partial N$ from the ambient level to N, the noise level at the house is

$$\int_0^{\bar{N}} -\gamma p f'(n)\,dN = -\gamma p f(N)\Big|_0^{\bar{N}}$$

and represents the noise damages to that house.

TABLE 4-10

Kingsgate Noise Damages

Zone	dBA L_{10}	Relative Reduction in House Price (%/100)	Reduction in Value of Average House (1977 dollars)
1	55 - 57.5	-.01190	- 604.06
2	57.5 - 60	-.02380	-1208.12
3	60 - 62.5	-.03570	-1812.18
4	62.5 - 65	-.04760	-2416.24
5	65 - 67.5	-.05950	-3020.30
6	67.5 - 70	-.07140	-3624.36

When there are left-out variables in a regression, bias is introduced in the estimates of the remaining coefficients. The amount of the bias can be quantified. If the truth is

$$Y_k = \sum_{i=1}^{m} \beta_i x_{ik} + \sum_{j=m+1}^{n} \beta_j x_{jk} + \varepsilon_k, \tag{4.2}$$

but the estimated equation is

$$Y_k = \sum_{i=1}^{m} b_i x_{ik} + \varepsilon_k, \tag{4.3}$$

then

$$E\ (b_i) = \beta_i + \sum_{j=m+1}^{n} \beta_j b_{ji.\gamma}. \tag{4.4}$$

Here the β_i represent the true coefficients of the left-out variables and $b_{ji.\gamma}$ is Yule notation for the coefficient of x_i in a hypothetical regression with the left-out variable x_j as the dependent variable and the included independent variables in equation 4.3 as the independent variables. The independent variables other than x_i are represented by γ . Thus, the bias of the estimate is

$$\text{Bias} = \sum_{j=m+1}^{n} + \beta_j b_{ji.\gamma} \tag{4.5}$$

In the aggregated regression the left-out variables are the yearly dummy variables multiplied times the characteristic variables. The previous Chow test has shown that at least some of the β_j are significantly different from zero. However, the hypothetical Yule regressions must also be non-zero to cause bias. Since a majority of the houses in the impact area were constructed before the highway was built, it is doubtful that the noise level now would be significant in explaining the characteristics for a sale in a particular year. It is also doubtful that tastes for quiet changed significantly in the five years of highway's existence. For these reasons there was probably little bias introduced by the aggregation, so the gain in precision justifies this procedure. Thus, the figures in Table 4.10 represent the best estimates of the noise damages in this area. These are the relevant estimates for considering the distributional effects of I-405 on property owners within the study area.

It was also of interest to see if the impact of adverse highway effects could be measured without direct noise measurements. Detailed procedures for traffic noise prediction are described in Galloway, et. al. (1969), Gordon, et. al. (1971), and Kugler and Piersol (1973). A two-step procedure using such models to predict the noise levels and the results here to translate these noise predictions to property value effects is possible. In this study a simplified procedure was desired where the property value effects were predicted from a limited number of characteristics such as distance from the highway and elevation with respect to the highway.

The hedonic regression was again run, but instead of INOISE, various forms of distance from the highway were used as well as elevation above or below the highway and a dummy variable representing trees between the house and the highway. However, beyond a certain distance from the highway, a marginal increase in distance would probably have no effect on property values. For this reason, the distance measurements were converted to distances from the ambient zone moving toward the highway. Various functional forms for the distance variable were tried. The same forms were used as were tried with the noise measurements, and the exponential of the distance from the ambient zone, EAMB, provided the best fit. The square of the distance proved to be an almost equivalent alternative. The elevations above and below the highway were entered as separate variables, POSELEV and NEGELEV, since noise measurement experiments indicate that there are differential effects. Finally, the presence of a dense stand of evergreen trees between the house and the highway was indicated by a dummy variable, NTREES. The results of this hedonic regression are reported in Table 4.11. Examples of price reductions due to highway proximity are given in Table 4.12. The effect of POSELEV is not statistically significant, but highway proximity damages are mitigated by distance below the highway and by the presence of trees. However, the coefficient of NTREES is probably larger than can be explained simply by noise mitigation, considering experiments which have been done on the effect of trees on noise levels. This variable may be measuring effects additional to noise mitigation, or it may be correlated with left-out variables such as subdivision quality.

It might be noted that in both the Kingsgate results reported in this chapter and the north King County results reported in the following chapter, the t-statistic for the distance variable is slightly larger than the t-statistic for the noise variable. The two statistics are each significant even at the .001 level. However, because the specification of the two equations differs and the number of independent variables differs one cannot make any statistical inference about the appropriateness of the two specifications.

TABLE 4.11

HEDONIC REGRESSIONS WITH LPRICE AS THE DEPENDENT VARIABLE AND DISTANCE MEASUREMENTS

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTIC	COEFFICIENT EVALUATED AT MEAN PRICE
GRADE	0.6619815×10^{-1}	0.00454	14.576	1851.408
AGE	$-0.7640826 \times 10^{-2}$	0.00055	13.978	- 213.696
AREA1ST	0.2315733×10^{-3}	0.00001	39.963	6.477
AREA2ND	0.1918792×10^{-3}	0.00000	43.094	5.366
FINHALF	0.1894159×10^{-3}	0.00002	10.400	5.298
BSMTAREA	0.7747096×10^{-4}	0.00001	15.289	2.167
FINBASE	0.5516847×10^{-4}	0.00001	7.545	1.543
DAYLIGHT	0.1994179×10^{-1}	0.00410	4.869	563.323
FINATTIC	0.4910704×10^{-4}	0.00001	5.836	1.373
UNFINATT	0.4127194×10^{-4}	0.00001	5.095	1.134
BATHS	0.7134302×10^{-1}	0.00411	17.354	1995.297
BSMTGAR	0.1268549×10^{-3}	0.00001	13.580	3.548
ATTGAR	0.1145448×10^{-3}	0.00001	11.167	3.204
CONCAREA	0.1910859×10^{-4}	0.00000	4.806	.534
BUILTINS	0.1297877×10^{-1}	0.00127	10.232	362.986
FRPL	0.2358178×10^{-1}	0.00278	8.485	659.527
PARKDIST	$-0.7807331 \times 10^{-3}$	0.00084	.928	- 21.835
WESTHWY	$-0.1852197 \times 10^{-1}$	0.00390	4.751	- 513.248
NGHGROUP	0.2542795×10^{-1}	0.00400	6.358	720.279
LOTAREA	0.3624358×10^{-6}	0.00000	.584	.010
TREES1	0.3883506×10^{-1}	0.00473	8.216	1086.126
D62	-0.1948076	0.01385	14.061	
D63	-0.1663208	0.01359	12.235	
D64	-0.1467592	0.02010	7.302	
D65	-0.1601619	0.01306	12.264	
D66	-0.1375329	0.00714	17.862	
D68	0.6251131×10^{-1}	0.00646	9.682	
D69	0.1121101	0.00647	17.323	
D70	0.1131258	0.00688	16.442	
D71	0.1066058	0.00720	14.802	
D72	0.1592263	0.00724	22.001	
D73	0.2446242	0.00696	35.159	
D74	0.3275553	0.00712	46.026	
D75	0.4366808	0.00688	63.488	
D76	0.5017868	0.00717	69.962	
EAMB	$-0.1959227 \times 10^{-3}$	0.00005	4.341	- 5.471
NTREES	0.3187340×10^{-1}	0.01344	2.372	891.424
POSELEV	$-0.4469788 \times 10^{-3}$	0.00026	1.722	- 12.501
NEGELEV	0.1273225×10^{-2}	0.00032	4.003	35.609
(CONSTANT)	8.931104			

R-SQUARE	0.90165
ADJUSTED R-SQUARE ($\bar{R}^2$)	0.90084
STANDARD ERROR	0.08258

TABLE 4.12

KINGSGATE PROXIMITY DAMAGES

Distance from highway	Relative Reduction in House Price (%/100)	Reduction in Value of Average House (1977 dollars)
within 100 '	-.07904	-4012.20
100-200'	-.02908	-1476.01
200-300'	-.01070	-542.71
300-400'	-.00394	-199.76
400-500'	-.00145	- 73.49
500-600'	-.00053	- 27.03
Trees between house and highway	.03239	1644.00
Distance above highway	-.00045	- 22.69
Distance below highway	.00127	64.63

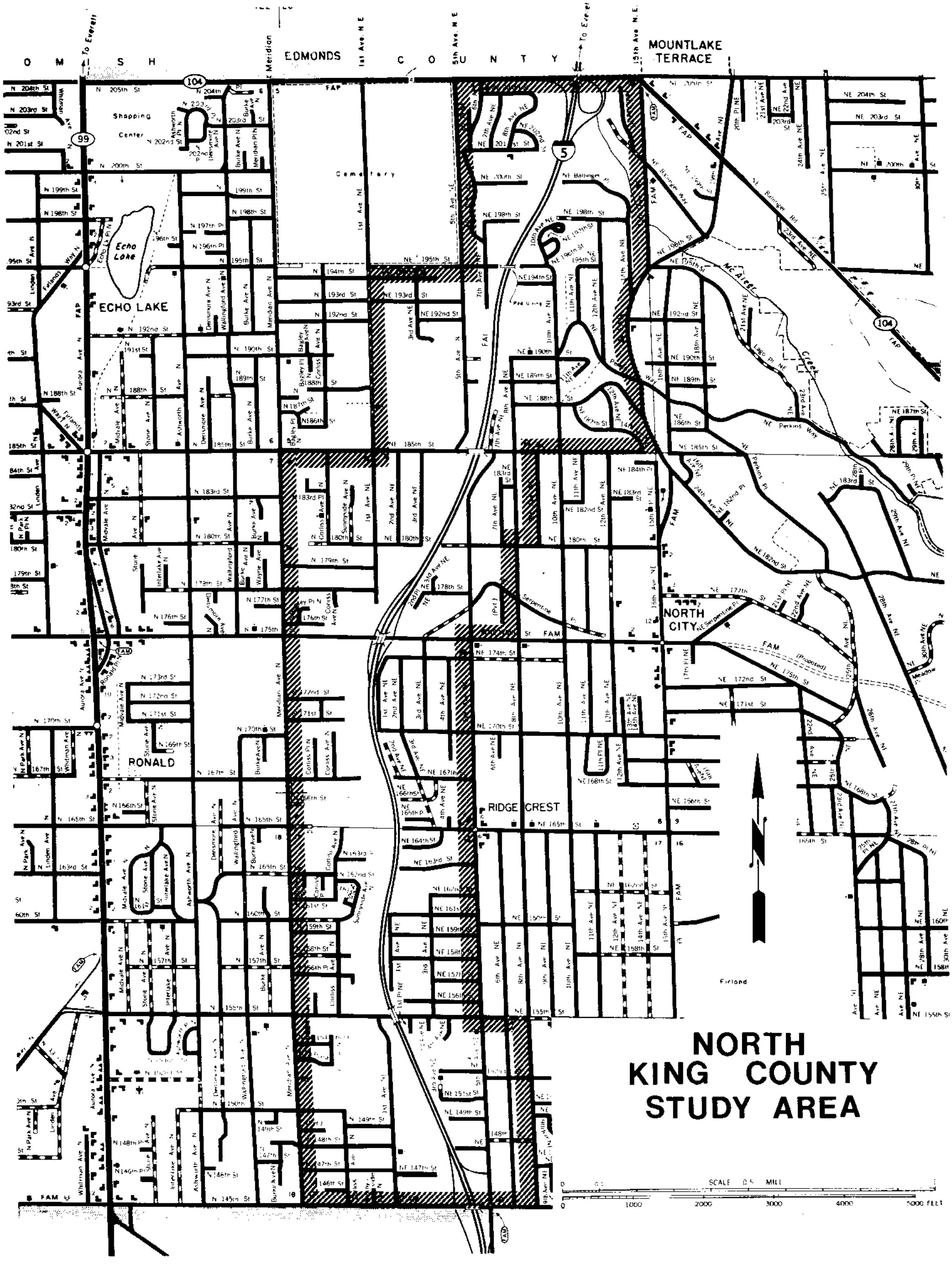
Chapter Five

North King County Study Area

The second study area which was utilized bordered Interstate 5 north of Seattle. This relatively homogeneous lower-middle class neighborhood contains homes that average 25 years old. Interstate 5, which in this section has six through lanes with two more lanes in connection with exits or entrances, was opened in late 1965. Thus, most of the houses were built before the highway location was announced.

The area borders the highway from the north city limits of Seattle north approximately three miles to the Snohomish County line. The area is bordered by NE 145th Street and NE 205th Street on the south and north respectively and by Meridian Avenue N and 15th Avenue NE on the west and east respectively. The distances of the houses from the highway ranged from less than 100 feet to 1900 feet. Although there is some undeveloped land in the area, the study was restricted to platted land with single-family residences. Highway access is provided at either end of the study area and at NE 175 Street. As in Kingsgate, the terrain is gently rolling with less than 200 feet of elevation difference.

Since this location was also within King County, the same excellent data sources were available as for the Kingsgate study. The variables collected are listed in Table 4.1 of the Kingsgate chapter with the exception of BUSYST, a dummy variable representing houses abutting through streets which replaced JWDIST. All valid sales beginning in 1958 and continuing through 1976 were collected, which yielded



NORTH KING COUNTY STUDY AREA

a data base of 2,823 observations. The nominal prices ranged from $4,950 to $58,950 with a mean of $18,568. When the prices were deflated by the Seattle real estate market price index, the real prices in 1976 dollars ranged from $4,274 to $46,635 with a mean of $17,495. These sales data were obtained from the real estate excise tax records and were restricted to valid sales by the procedures described previously. Data on the house and lot characteristics were obtained from the King County Assessor's records, and the direct measurements of highway noise and distance were made as previously described.

Almost all of the houses in the area are one-story with only four percent of the sales representing one-and-a-half or two-story houses. The average first-floor area was 1067 square feet with a range from 400 to 2610 square feet. The average total finished area including basements and attics was 1225 square feet, while the average house contained 188 square feet of unfinished living space. Most of the houses had a garage (86%) with 68 percent of the garages having only one stall. The average age at the time of sale was 13 years with a range from 0 to 55 years.

Noise monitoring was done at a total of 57 different locations with two or three readings at peak hours taken at each location. Noise contour lines were then developed with allowed assignment of a noise level for each house. Sales after the highway opened represented 436 observations where highway noise caused the level to be significantly above the ambient level of the surrounding neighborhood.

These included 189 houses where the peak-hour L_{10} reading was between 55 and 60 dBA, 147 between 60 and 65 dBA, 68 between 65 and 70 dBA, and 32 where the reading was between 70 and 75 dBA. The readings are summarized in Table 5-1.

Table 5-1

North King County

Noise Readings

Zone Number	dBA L_{10} Interval	Number of Observations
1	55 - 57.5	98
2	57.5 - 60	91
3	60 - 62.5	67
4	62.5 - 65	80
5	65 - 67.5	39
6	67.5 - 70	29
7	70 - 72.5	25
8	72.5 - 75	7

As with the data from the Kingsgate area, the data for the North King County study area were analyzed by alternative methods to provide a check on the techniques being used. The primary method again was hedonic regression. The variables were for the most part selected on theoretical grounds as before. Since this area is not as homogeneous as Kingsgate, a few more variables were needed to describe the different houses. For example, detached garages were present in some houses in this area; not all houses had underground utilities; and a variety of heating sources were used. On the other hand, none of the plats had recreation facilities. Facts such as these account for the minor differences in variables between the areas. The results of the final regression are reported in Table 5-2. Once again the coefficients are all of the expected sign and reasonable magnitude. The coefficients are also comparable with those derived in Kingsgate with the same relationships between the coefficients.

Access Benefits

The coefficients of the time dummy variables could be utilized to develop a real estate price. Such an index is included in Table 5-3. However, the validity of this index depends on aggregating the data over time. The acceptability of such a procedure can be checked using the Chow tests or F-tests described earlier. Separate hedonic regressions were run on each of the years of the study. The sum of the residual sums of squares was 33.52584 for the separate regressions while in the aggregate regression reported above the residual sum of squares was 42.93111. With these figures the hypothesis of the acceptability of aggregation could be tested with the calculated F-statistic of 7.354 with 459 and 2319 degrees of freedom in the numerator and denominator respectively. This exceeds the critical value of 1.13 at the 95 percent confidence level. Thus, aggregation was strongly rejected and might be expected to introduce bias into the estimates of the coefficients of the time dummy variables. Further

Table 5-2

NORTH KING COUNTY
HEDONIC REGRESSION WITH LPRICE AS THE DEPENDENT VARIABLE
AND MEASURED NOISE LEVELS

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTIC	COEFFICIENT EVALUATED AT MEAN PRICE
GRADE	0.3655653D-01	0.00444	8.226	678.769
AGE	-0.7639764D-02	0.00054	14.041	-141.852
AREA1ST	0.3132892D-03	0.00001	23.006	5.817
AREA2ND	0.1286713D-03	0.00002	8.251	2.389
FINHALF	0.1903141D-03	0.00006	3.341	3.534
BSMTAREA	0.1104960D-03	0.00001	11.765	2.052
FINBASE	0.2300718D-04	0.00001	1.690	.427
DAYLIGHT	0.8300951D-02	0.00904	.919	154.771
FINATTIC	0.1019502D-03	0.00004	2.875	1.893
BATHS	0.6982050D-01	0.00924	7.553	1296.402
BSMTGAR	0.1258151D-03	0.00002	6.597	2.336
ATTGAR	0.1590696D-03	0.00002	8.140	2.954
DETGAR	0.1066097D-03	0.00002	4.638	1.979
CARPORT	0.1387460D-03	0.00002	6.480	2.576
CONCAREA	0.4323145D-04	0.00001	5.436	.803
ASPHAREA	0.1763429D-04	0.00001	2.005	.327
BUILTINS	0.9406335D-02	0.00279	3.374	174.654
FRPL	0.3743461D-01	0.00486	7.706	695.073
UND	0.2943193D-01	0.01277	2.304	554.603
BRICK	0.3029907D-01	0.01013	2.991	571.192
DECK	0.1083763D-03	0.00003	3.727	2.012
GAS	0.2787489D-01	0.00874	3.189	524.852
OIL	0.4503516D-01	0.00805	5.594	855.312
BUSYST	-0.1863661D-01	0.00699	2.665	-349.283
WESTHWY	0.2554088D-01	0.00572	4.464	480.342
TREES1	-0.2729722D-01	0.00681	4.006	-513.826
LOTAREA	0.1812412D-05	0.00000	2.152	.034
D58	-0.4207466	0.07271	5.786	
D59	-0.2560057	0.01795	14,262	
D60	-0.2340462	0.01357	17.247	
D61	-0.2169563	0.01327	16.351	
D62	-0.1804901	0.01188	15.191	
D63	-0.1600943	0.01214	13.193	
D64	-0.1661289	0.01330	12.495	
D65	-0.1776561	0.01336	13.295	
D66	-0.9316404D-01	0.01241	7.506	
D68	0.8925296D-01	0.01329	6.716	
D69	0.1485819	0.01374	10.814	
D70	0.1429087	0.01464	9.760	
D71	0.1269029	0.01606	7.901	
D72	0.1596334	0.01455	10.969	
D73	0.2101414	0.01437	14.622	
D74	0.3168724	0.01444	21.939	
D75	0.4137303	0.01422	29.098	
D76	0.5574032	0.01560	35.722	
INOISE	-0.7488671D-02	0.00191	3.911	-139.047
(CONSTANT)	8.987655			

R SQUARE	0.85857
ADJUSTED R SQUARE ($\bar{R}^2$)	0.85622
STANDARD ERROR	0.12436

Table 5-3

North King County

Real Estate Price Indexes

Year	Index from Aggregate Hedonic Regression	Index from Chain Hedonic Regressions
58	.657	.684
59	.774	.776
60	.791	.798
61	.805	.817
62	.835	.845
63	.852	.862
64	.847	.857
65	.837	.849
66	.911	.922
67	1.000	1.000
68	1.093	1.095
69	1.160	1.170
70	1.154	1.155
71	1.135	1.147
72	1.173	1.179
73	1.234	1.284
74	1.373	1.384
75	1.512	1.529
76	1.746	1.756

F-tests were used to test the validity of combining adjacent pairs of years to develop the chain hedonic index. Such aggregation was acceptable at the .05 level for fourteen of the pairs and was acceptable at the .025 level for two additional pairs. Aggregation was rejected for only one pair of years, and this pair was before the opening of the highway. It is interesting to note that the two pairs that were only acceptable at the .025 level involved the three years when Interstate 5 right-of-way was being purchased and the highway built. This corresponds with the Kingsgate result that some instability is introduced in the real estate market during the highway construction. In any event, the pairwise aggregation is acceptable, and the chain index is also reported in Table 5-3.

Over 56 percent of the houses in the area were sold two or more times during the period studied, and some houses were sold as many as six times. This provided an excellent data base for developing an alternative real estate price index using the resale techniques. Pairs of sales on the same house were combined to form price relatives which were then adjusted for depreciation between the two sales using the hedonic estimate as discussed earlier. There were 1960 sales-pairs derived by this method. However, the hedonic data had revealed that the characteristics of some houses were changed between sales. Also, the houses closest to the highway also suffered some noise damages after the highway was opened. Since the hedonic study compensated for this noise damage in deriving the index, the same would be desirable here. Thus, the data were separated into four groups according to whether or not the house characteristics had changed and whether or not the house was affected by highway noise. F-tests were then used to examine the validity of aggregating these different groups. In all cases aggregation was rejected. For this reason, the only index which applies in the same situation as the hedonic index is for houses without highway noise or characteristics change. There were 795 observations that met these conditions. The results of this regression are reported in Table 5-4, along with 95 percent confidence intervals on the index estimates.

A comparison of the hedonic and the resale indexes reveals a close correspondence. In fact the two indexes are statistically equivalent in all of the years except two, 1960 and 1962. These two years are both before the highway opened and thus not crucial for this study. Thus, the resale index provides a reliable representation of the trend in real estate prices in the area, and the specification in the hedonic regression, which is used to assess highway noise effects, performs well.

The Seattle Real Estate Research Committee has an index representing real estate trends in north Seattle, north King County, and southern Snohomish County. This index represents the general location and type of homes in the study area. This control index is reported in Table 5-5, along with the resale index for the highway study area. Both have been normalized in 1965, the year the highway was opened. The two indexes have also been shown graphically in Figure 5-1. It can be seen that the two indexes track together very well in the years before the highway was opened. After the highway opened, homes near the highway appreciated considerably more rapidly than those represented

Table 5-4

MULTIPLE SALE REGRESSION WITH HEDONIC DEPRECIATION ESTIMATE

Variable	Coefficient	Standard Error	Index	95% Confidence Interval Low	High
YR58	-0.487	0.085	.614	.520	.726
YR59	-0.281	0.027	.755	.716	.796
YR60	-0.285	0.018	.752	.726	.779
YR61	-0.227	0.017	.797	.771	.824
YR62	-0.218	0.016	.804	.779	.830
YR63	-0.184	0.018	.832	.803	.862
YR64	-0.184	0.020	.832	.800	.865
YR65	-0.201	0.020	.818	.786	.851
YR66	-0.112	0.018	.894	.863	.926
YR67	-	-	1.000	1.000	1.000
YR68	.118	0.020	1.125	1.082	1.170
YR69	.158	0.019	1.171	1.128	1.216
YR70	.138	0.021	1.148	1.102	1.196
YR71	.114	0.021	1.121	1.076	1.168
YR72	.172	0.023	1.188	1.135	1.242
YR73	.182	0.023	1.200	1.147	1.255
YR74	.305	0.018	1.356	1.310	1.405
YR75	.422	0.019	1.525	1.469	1.583
YR76	.567	0.019	1.763	1.699	1.830

R-SQUARE 0.8610
STANDARD ERROR 0.1469

by the control index. There was a dip in the resale index between 1969 and 1973. This aberration is easily accounted for since these are the years of the Boeing downturn. Many Boeing workers choose to live in areas such as Kingsgate and this north King County area because these locations are central between Everett and Renton where Boeing has plants.

Such houses command a premium because of the accessibility which the highway affords. When Boeing cut its employment by well over half and there were substantial secondary employment cuts, many of the residents of such areas were forced to sell, and the premium for accessibility was reduced. After the slump the differential was reestablished. The differential, with the exception of the years of the downturn, appears to have been about a fifteen percent appreciation because of the accessibility benefits. This appreciation does not appear to have taken place on the announcement of the highway but rather upon the opening of the highway.

Noise Damages

The possibility of adverse effects on property values because of negative environmental influences of the highway was also investigated using the hedonic regressions discussed earlier. The noise contours derived from the noise monitoring were used to assign a noise level to each house. The 2 1/2 dBA L_{10} contour lines were converted to a scale where the ambient level had a value of zero and each 2 1/2 dBA increment above ambient increased the scale by one. The variable thus created, INOISE, was assigned to all sales that took place after the opening of the highway.

Table 5-5

Comparison of I-5 North King County Index
with Control Index (normalized on highway opening, 1965)

Year	I-5 North King County Index	Control Index
59	.923	.94
60	.919	.95
61	.974	.96
62	.983	.98
63	1.017	1.00
64	1.017	1.00
65	1.000	1.00
66	1.056	1.01
67	1.222	1.05
68	1.375	1.15
69	1.432	1.31
70	1.403	1.33
71	1.370	1.34
72	1.452	1.39
73	1.467	1.44
74	1.656	1.47
75	1.864	1.62
76	2.155	1.76

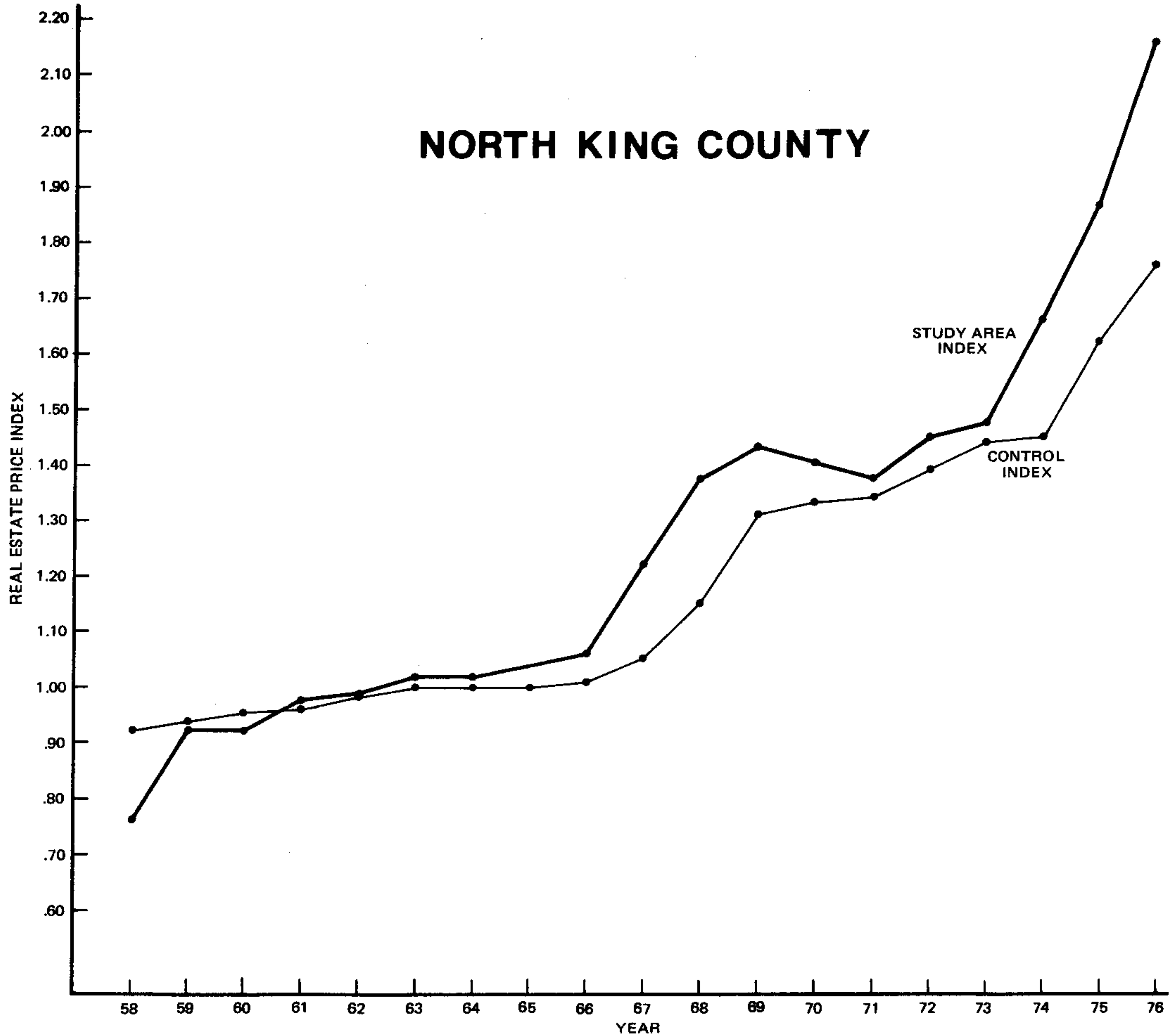

NORTH KING COUNTY
REAL ESTATE PRICE INDEX
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
.60
STUDY AREA INDEX
CONTROL INDEX
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
YEAR

Figure 5.1

Alternative functional forms for the noise variable were tried as with Kingsgate. The linear form performed slightly better than the alternative forms, and this is the form in the reported regression. Table 5-6 reports the estimated noise damages for the range of noise levels observed. These results are similar to those in Kingsgate, but they are somewhat lower in absolute value. This does not represent an inconsistency in the two studies, but rather the fact that willingness to pay for quiet appears to increase with income. The residents of Kingsgate have higher mean income than those in the north King County study area, which would account for the difference in the magnitude of the influence of noise on property values.

The influence of highway noise on property values was also estimated without using direct noise measurement. The hedonic regressions were run using distance from the highway, elevation with respect to the highway, and whether there was a stand of evergreen trees between the house and the highway. The noise readings had indicated that highway noise was negligible beyond 650 feet from the highway. The variable AMBDIST represented the distance of the house beyond this ambient zone. As with the noise readings, alternative functional forms were used to find which best approximated human reaction to distance from the highway. The empirically most appropriate form proved to be AMBSQ, the square of the distance from the ambient zone measured in 100-foot units. The results of this regression are reported in Table 5-7. The distance coefficient is comparable to the one in the Kingsgate study, although smaller.

Table 5-6

North King County Noise Damages

Zone	dBA L_{10}	Relative Reduction in House Price (% /100)	Reduction in Value of Average House (1977 Dollars)
1	55 - 57.5	-0.00749	-268.69
2	57.5 - 60	-0.01498	-537.37
3	60 - 62.5	-0.02247	-806.06
4	62.5 - 65	-0.02995	-1074.74
5	65 - 67.5	-0.03744	-1343.43
6	67.5 - 70	-0.04493	-1612.12
7	70 - 72.5	-0.05242	-1880.81
8	72.5 - 75	-0.05991	-2149.49

The effect of income on people's willingness to pay for quiet again accounts for this. Being either above or below grade partially offsets the highway proximity, although neither coefficient is now significantly different from zero. Trees between the house and highway have a significant effect in reducing the proximity damages. These results, including the effects on a house of mean value, are shown in Table 5-8.

TABLE 5-7

NORTH KING COUNTY
HEDONIC REGRESSIONS WITH LPRICE AS THE DEPENDENT VARIABLE
AND DISTANCE MEASUREMENTS

Variable	Coefficient	Std Error	T-Statistic	Coefficient Evaluated at Mean Price
GRADE	0.3596499D-01	0.00445	8.074	667.785
AGE	-0.7658383D-02	0.00054	14.091	-142.198
AREA1ST	0.3105012D-03	0.00001	22.789	5.765
AREA2ND	0.1288944D-03	0.00002	8.287	2.393
FINHALF	0.1862125D-03	0.00006	3.276	3.348
BSMT AREA	0.1102118D-03	0.00001	11.736	2.046
FINBASE	0.2446210D-04	0.00001	1.797	.454
DAYLIGHT	0.7478145D-02	0.00902	.829	139.372
FINATTIC	0.1011021D-03	0.00004	2.856	1.877
BATHS	0.6897027D-01	0.00925	7.455	1280.616
BSMTGAR	0.1263995D-03	0.00002	6.642	2.347
ATTGAR	0.1560774D-03	0.00002	7.993	2.898
DETGAR	0.1088565D-03	0.00002	4.747	2.021
CARPORT	0.1362624D-03	0.00002	6.379	2.530
CONCAREA	0.4127423D-04	0.00001	5.175	.766
ASPHAREA	0.1724667D-04	0.00001	1.969	.320
BUILTINS	0.9542092D-02	0.00279	3.426	177.174
FRPL	0.3718637D-01	0.00485	7.667	690.463
UND	0.3299513D-02	0.01279	2.580	622.861
BRICK	0.3115347D-01	0.01012	3.078	587.551
DECK	0.1104185D-03	0.00003	3.789	2.050
GAS	0.2720825D-01	0.00874	3.113	512.128
OIL	0.4443722D-01	0.00803	5.535	843.702
BUSYST	-0.1917665D-01	0.00698	2.746	-352.673
WESTHWY	0.2877191D-01	0.00579	4.971	541.986
TREES1	-0.3305548D-01	0.00747	4.428	-603.729
LOTAREA	0.1995939D-05	0.00000	2.360	.037
D58	-0.4207411	0.07257	5.798	
D59	-0.2584040	0.01796	14.387	
D60	-0.2363038	0.01360	17.377	
D61	-0.2191676	0.01331	16.462	
D62	-0.1828825	0.01192	15.338	
D63	-0.1622401	0.01218	13.324	
D64	-0.1687143	0.01333	12.654	
D65	-0.1798493	0.01341	13.407	
D66	-0.9381391D-01	0.01239	7.574	
D68	0.9105851D-01	0.01328	6.855	
D69	0.1494442	0.01371	10.901	
D70	0.1430119	0.01463	9.775	
D71	0.1270325	0.01603	7.923	
D72	0.1601127	0.01453	11.021	
D73	0.2104349	0.01436	14.651	
D74	0.3163777	0.01441	21.953	
D75	0.4130957	0.01418	29.123	
D76	0.5566571	0.01557	35.755	
AMBSQ	-0.1695864D-02	0.00031	5.418	-31.488
NTREES	0.6546076D-01	0.02753	2.378	1256.117
POSELEV	0.5374579D-03	0.00032	1.683	9.979
NEGELEV	0.7438277D-03	0.00258	.288	13.811
(CONSTANT)	8.998165			

R SQUARE 0.85936
ADJUSTED R SQUARE ($\bar{R}^2$) 0.85687
STANDARD ERROR 0.12408

Table 5-8

North King County Highway Proximity Damages

Distance to Highway	Relative Reduction in House Price (%/100)	Reduction in Value of Average House (1977 Dollars)
Within 100'	-.06105	-2190.07
100 - 200	-.04240	-1520.88
200 - 300	-.02713	-943.36
300 - 400	-.01526	-547.52
400 - 500	-.00678	-243.34
500 - 600	-.00170	-60.84
Trees Between House and Highway	.06546	2348.23
Distance Above Highway	.00054	19.28
Distance Below Highway	.00074	26.68

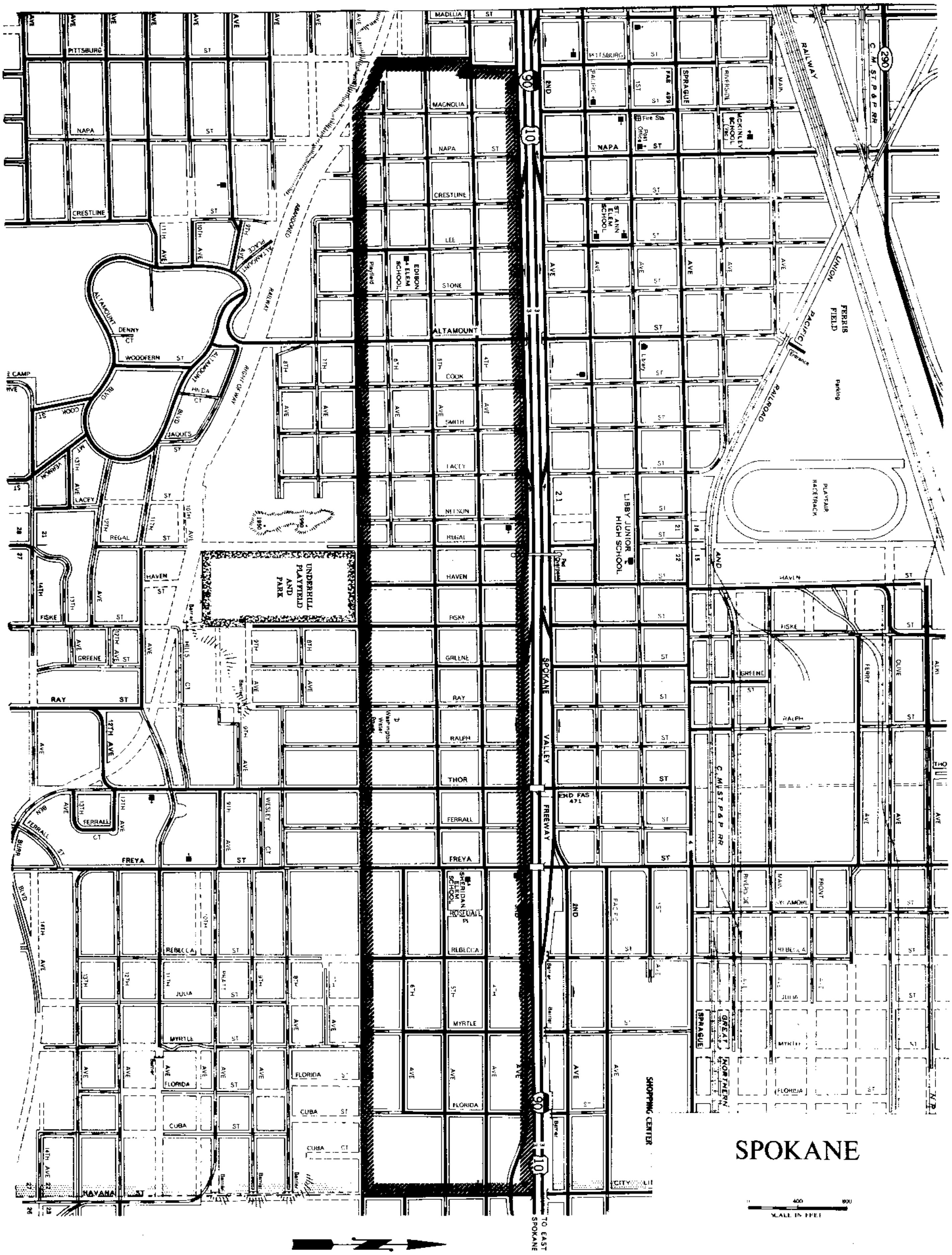
Chapter Six

Spokane Study Area

Another study area was selected along Interstate 90 through Spokane. Here a major urban freeway passes through an area of older homes that were built before the highway was opened. The average age of the houses is fifty years, while the highway was opened in early 1959 to carry the traffic that had previously used Sprague Avenue. This was only one of a number of changes that may have affected property values in this area over the years. Nonetheless, this area of lower-class homes provided an increased range of socio-economic neighborhoods being studied.

The study area is just inside the east city limits of Spokane and south of Interstate 90. It is bordered on the east by Havana St. and on the west by Pittsburg St. Interstate 90 forms the north boundary, and the area goes south to Hartson Ave. This is the only residential study area that did not include houses on both sides of the highway. This is because houses north of the highway are within close proximity to Sprague Avenue which is lined with commercial establishments. Additional stores are located throughout the area. Since such an area did not meet the requirements of a relatively pure residential area without incentives for speculation on use change.

Over half of the houses were built before 1920 and less than five percent were constructed after 1950. The average house contained 865 square feet with a range from 416 to 1516 square feet. A majority of


SPOKANE
SCALE IN FEET
0
400
800
TO EAST SPOKANE
SPOKANE VALLEY FREEWAY
UNDERHILL PLAYFIELD AND PARK
LIBBY JUNIOR HIGH SCHOOL
FERRIS FIELD
PLAYFAIR RACETRACK
SHOPPING CENTER
EDISON ELEM SCHOOL
ST. ANN ELEM SCHOOL
MCKINLEY SCHOOL
SHERIDAN ELEM SCHOOL
UNION PACIFIC RAILROAD
C M ST P & P RR
END FAS 471
PITTSBURG
NAPA
CRESTLINE
ALTAMOUNT
HAVEN
FISKE
GREENE
RAY
RALPH
THOR
FERRALL
FREYA
REBECCA
JULIA
MYRTLE
FLORIDA
CUBA
HAVANA

homes were single story, although approximately a third were classed as story-and-a-half. The average house had only one bath and a single car garage.

The highway through this section has three lanes in each direction with a narrow median. The average daily traffic volume in 1976 was 45,351 at the Havana St. crossing. There are four streets within the study area which cross the highway in addition to a pedestrian overpass. Third Avenue is a one-way street which serves as a frontage road to the highway. There are two off ramps and two on ramps in each direction in this section of highway. The terrain variations are very small here with most houses approximately level with the highway. The study area only went back from the highway a maximum of 1300 feet because a steep hillside forms a natural southern boundary. Noise monitoring was carried out at 41 locations during afternoon peak traffic hours. Some readings went as high as 80 dBA L_{10} because of the level terrain without vegetation, although most readings were below 70 dBA L_{10}. The average noise levels at each house were estimated from the noise contour lines derived. These estimates are summarized in Table 6-1.

Data on sale prices and dates, as well as the characteristics of the houses, were collected from the Spokane County Assessor's records. The difference in the information collected by that county accounts for the slight alterations that were necessary in the variables used. The variables selected are defined in Table 6-2. Information on the most important variables, such as age and square feet of living space, was available as before.

Table 6-1

Spokane Noise Readings

Zone	dBA L_{10} Interval	Number of Observations
1	55 - 57.5	29
2	57.5 - 60	41
3	60 - 62.5	28
4	62.5 - 65	5
5	65 - 67.5	29
6	67.5 - 70	42
7	70 - 72.5	11
8	72.5 - 75	38
9	75 - 77.5	10
10	77.5 - 80	9
11	80 - 82.5	1

Table 6-2

Spokane Variable Definitions

AGE	Age of House at Time of Sale
GRADE	Quality Rating
AREA1ST	First Floor Area
AREA2ND	Second Floor Area
ATAREA	Attic Area
BSMTAREA	Basement Area
BSMTFLR1	Concrete Basement Floor
FLR1	Hardwood Floors
PLFIXT	Number of Plumbing Fixtures
FRPL	Number of Fireplaces
FND1	Concrete Foundation
GARAREA	Garage Area
CARPORT	Carport Area
PORCH	Porch Area
LOTAREA	Lot Area
INOISE	Noise Contour
D50-D78	Dummy Variables Representing Year of Sale

Hedonic regressions were again used to estimate the contribution of the various characteristics to the value of the house. The functional form and certain variables were selected empirically. The results of the selected regression are reported in Table 6-3. Almost all of variables have reasonable magnitudes and the correct relationship to the other variable coefficients. In a few of the minor variables, the coefficient is larger than expected. This is not crucial since these variables do not apply to most houses. The coefficients of the time dummy variables were used to calculate the real estate price index for this area. This is reported in Table 6-4.

It was hoped that this index could be used to examine the effect of the highway on property values, but several problems were encountered. There are no real estate price indexes for the Spokane area. Such indexes in King and Snohomish counties were most useful as a control. The alternative of using a specific control area and developing an index was investigated. The problem here was in finding an area that was comparable to the study area in all respects other than the highway. Within the study area there were changes in the ethnic composition of the neighborhood that took place during the period studied. Such changes may well have affected property values, and no comparable control area existed which experienced similar changes during the same period. National real estate price indexes could not be used since there was a local downturn in the Spokane area in the early sixties.

TABLE 6-3

SPOKANE HEDONIC REGRESSION WITH LPRICE AS THE DEPENDENT VARIABLE AND MEASURED NOISE LEVELS

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTICS	COEFFICIENT EVALUATED AT MEAN PRICE
AGE	-0.8003099E-02	0.00131	6.132	-68.594
GRADE	0.1197539	0.02429	4.930	1026.408
AREA1ST	0.4090636D-03	0.00012	3.463	3.506
PLFIXT	0.9714346D-02	0.01653	0.587	83.261
FRPL	0.9721993D-01	0.04232	2.297	833.269
ATAREA	0.2181561D-02	0.00129	1.682	18.698
AREA2ND	0.3543542D-03	0.00009	3.925	3.037
BSMTAREA	0.1978213D-03	0.00007	2.882	1.696
BSMTFLR1	0.1156931	0.04515	2.563	1051.241
FLR1	0.1091186	0.03868	2.821	988.187
GARAREA	0.4449337D-04	0.00011	0.402	.381
CARPORT	0.4309523D-03	0.00038	1.125	3.694
PORCHES	0.5618070D-03	0.00049	1.135	4.815
INOISE	-0.2002841D-02	0.00618	0.324	-17.166
LOTAREA	0.2654798D-04	0.00001	3.468	.228
FND1	0.9950911D-01	0.04083	2.437	896.768
D50	0.1988720	0.21863	0.909	
D51	0.3725406	0.20337	1.832	
D52	0.1674999	0.14290	1.172	
D53	0.3002470	0.15893	1.889	
D54	0.2144613	0.14683	1.460	
D55	0.4635143	0.12911	3.590	
D56	0.3073264	0.13430	2.288	
D57	0.3905192	0.13515	2.889	
D58	0.2914550	0.14678	1.986	
D59	0.1932543	0.14833	1.303	
D60	0.4243504	0.16183	2.622	
D61	0.7189241D-01	0.16149	0.445	
D62	0.6511715D-01	0.17018	0.382	
D63	-0.5440318D-01	0.14984	0.363	
D64	-0.6772006D-01	0.14655	0.463	
D65	-0.1655335	0.14159	1.169	
D66	-0.1633876	0.14008	1.166	
D68	0.9765719D-01	0.12938	0.755	
D69	0.1347674	0.12585	1.071	
D70	0.2948142	0.14021	2.103	
D71	0.4346045	0.12154	3.576	
D72	0.6354421	0.12087	5.257	
D73	0.7373331	0.11813	6.242	
D74	0.7239513	0.12579	5.755	
D75	0.8458703	0.12227	6.918	
D76	1.132879	0.12485	9.074	
D77	1.323349	0.11294	11.717	
D78	1.479614	0.12825	11.537	
(CONSTANT)	7.061432			

R SQUARE	0.68331
ADJUSTED R SQUARE ($\bar{R}^2$)	0.66341
STANDARD ERROR	0.42720

Table 6-4

Spokane Study Area Real Estate Price Index

Year	
50	1.220
51	1.451
52	1.182
53	1.350
54	1.239
55	1.590
56	1.360
57	1.478
58	1.338
59	1.213
60	1.529
61	1.075
62	1.067
63	.947
64	.935
65	.848
66	.849
67	1.000
68	1.103
69	1.144
70	1.343
71	1.544
72	1.888
73	2.090
74	2.063
75	2.330
76	3.105
77	3.756
78	4.391

For these reasons no quantitative statements can be made about the effects of the highway on property values. The downturn in the economy probably accounts for much of the slump in real estate prices in the sixties, although it is not possible to claim that the highway did not contribute to the effect. There is no evidence that the highway did or did not help or hurt property values. In any event, by the late sixties, property values rebounded and have been appreciating rapidly since then.

Although the absense of a control index does not allow statements about the behavior of real estate price over time, the hedonic regression yields the anticipated results and can be used to analyze possible noise damages. The coefficient of the noise variable is negative as expected and is smaller in absolute value than the coefficients estimated in the two previous studies. Again this accords well with the hypothosis that marginal willingness to pay for quiet increases with income since the income levels in this neighborhood are lower than in the others. The estimated noise damages at different noise levels are reported in Table 6-5. Table 6-6 reports the results of the hedonic regression using distance measurements instead of noise level measurements.

Table 6-5

Spokane Noise Damages

Zone	dBA L_{10}	Relative Reduction in House Price (%/100)	Reduction in Value of Average House (1977 dollars)
1	55 - 57.5	-.00200	-31.16
2	57.5 - 60	-.00401	-62.31
3	60 - 62.5	-.00601	-93.47
4	62.5 - 65	-.00801	-124.63
5	65 - 67.5	-.01001	-155.78
6	67.5 - 70	-.01202	-186.94
7	70 - 72.5	-.01402	-218.10
8	72.5 - 75	-.01602	-249.25
9	75 - 77.5	-.01803	-280.41
10	77.5 - 80	-.02003	-311.57
11	80 - 82.5	-.02203	-342.72

TABLE 6-6

SPOKANE HEDONIC REGRESSION WITH LPRICE AS THE DEPENDENT VARIABLE AND DISTANCE MEASURES

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTICS	COEFFICIENT EVALUATED AT MEAN PRICE
AGE	-0.7796443D-02	0.00131	5.962	-66.823
GRADE	0.1175895	0.02429	4.842	1007.857
AREA	0.4282820D-03	0.00012	3.611	3.671
PLFIXT	0.1055362D-01	0.01654	0.638	90.455
FRPL	0.1022553	0.04249	2.406	876.428
ATAREA	0.1493366D-02	0.00133	1.122	12.800
AREA2	0.3489825D-03	0.00009	3.857	2.991
BSMT AREA	0.1958817D-03	0.00007	2.815	1.679
BSMT FLR1	0.1204581	0.04508	2.672	1097.200
FLR1	0.1090615	0.03890	2.804	987.641
GARAREA	0.3767465D-04	0.00011	3.376	0.323
CARPORT	0.4445208D-03	0.00038	1.162	3.810
PORCHES	0.4746875D-03	0.00050	0.950	4.069
FND1	0.1013967	0.04104	2.470	914.657
LOTAREA	0.2803530D-04	0.00001	3.647	.240
D50	0.2252347	0.21878	1.030	
D51	0.3696193	0.20378	1.814	
D52	0.1762412	0.14316	1.231	
D53	0.3106567	0.15869	1.958	
D54	0.2294286	0.14663	1.565	
D55	0.4667124	0.12888	3.621	
D56	0.3228237	0.13419	2.406	
D57	0.4007385	0.13506	2.967	
D58	0.3033082	0.14657	2.070	
D59	0.1793774	0.14827	1.210	
D60	0.4353519	0.16199	2.688	
D61	0.8992736D-01	0.16150	0.557	
D62	0.5637610D-01	0.16982	0.332	
D63	-0.5148311D-01	0.14959	0.344	
D64	-0.8579096D-01	0.14648	0.586	
D65	-0.1717514	0.14155	1.213	
D66	-0.155.7852	0.13995	1.113	
D68	0.1020990	0.12931	0.789	
D69	0.1441868	0.12595	1.145	
D70	0.3007457	0.14006	2.147	
D71	0.4424503	0.12138	3.645	
D72	0.6300285	0.12071	5.219	
D73	0.7396769	0.11800	6.268	
D74	0.7252827	0.12556	5.776	
D75	0.8436874	0.12208	6.911	
D76	1.1227455	0.12472	9.000	
D77	1.327415	0.11288	11.760	
D78	1.489431	0.12813	11.624	
AMBDIST	-0.8428757D-02	0.00980	0.860	-72.243
POSELEV	0.3600222D-03	0.00452	0.008	3.086
NEGELEV	0.1035629D-01	0.00512	2.023	88.763
(CONSTANT)	7.024499			

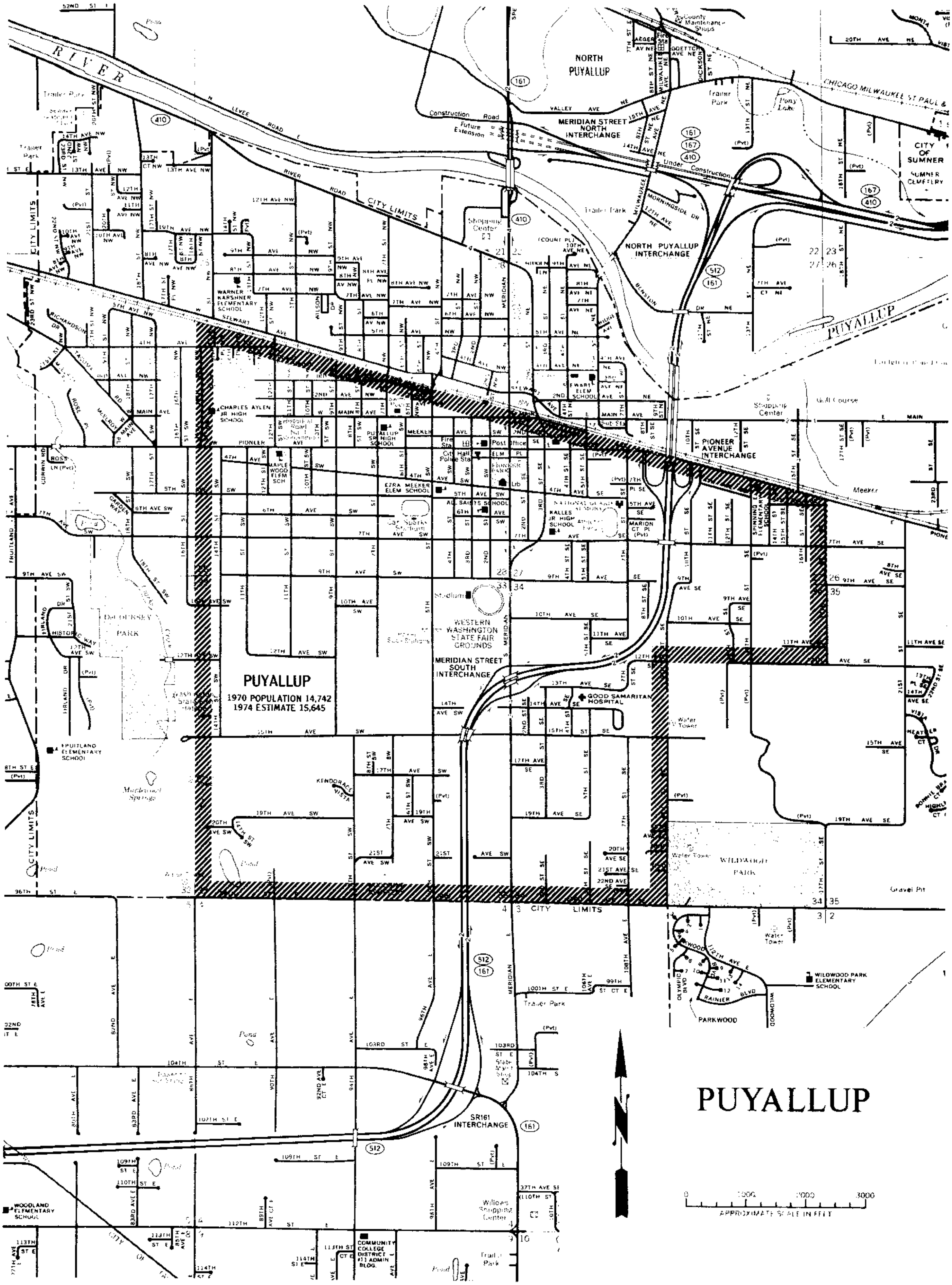
R SQUARE	0.68529
ADJUSTED R SQUARE ($\bar{R}^2$)	0.66455
STANDARD ERROR	0.42647

Chapter Seven

Puyallup Study Area

The final residential study area to be discussed is located in the southeast corner of Puyallup where SR 512 has recently been built. Much of this area is still relatively undeveloped with farm land or small residential acreages scattered among the more densely developed residential areas. The northwest part of the study area is older and more uniformly developed than the rest of the study area. SR 512 is a limited-access four lane highway that was opened in December of 1973. One of the main reasons for the study was to examine whether or not the houses located to the southeast of the highway appreciated more slowly because they had been isolated from the main part of the city. This was a concern that was frequently expressed prior to the construction of the highway.

The study area was bounded on the north by Pioneer Avenue, on the west by 16th Street SW, on the south by the Puyallup city limits, and on the east by 9th Street SE and 17th Street SE. A control area was also used which was bounded by the railroad tracks (Stewart Avenue) on the north and Pioneer Avenue on the south. Many of the residents of Puyallup work in the Tacoma area and commute by way of the River Road (SR 410) which joins I-5 east of Tacoma. After leaving Puyallup, SR 512 turns west and joins I-5 south of Tacoma, but it is not often used for commuting according to the residents.



PUYALLUP
PUYALLUP
1970 POPULATION 14,742
1974 ESTIMATE 15,645
NORTH PUYALLUP
CITY OF SUMNER
MERIDIAN STREET NORTH INTERCHANGE
NORTH PUYALLUP INTERCHANGE
PIONEER AVENUE INTERCHANGE
MERIDIAN STREET SOUTH INTERCHANGE
SR161 INTERCHANGE
WESTERN WASHINGTON STATE FAIR GROUNDS
GOOD SAMARITAN HOSPITAL
WILDWOOD PARK
CITY LIMITS
APPROXIMATE SCALE IN FEET

The data for this study were collected at the Pierce County Assessor's office and by direct measurement. Sale prices and dates were taken from the Assessor's records rather than excise tax affidavits because Pierce County does not have the affidavits cross-indexed by location as does King County. The sample of sales, while still accurate, is probably less complete than in the previous studies. Sales were collected which took place between 1965 and 1976 inclusive. This provided a data base of 838 sales. The mean price was $17,345 with a range from $2,877 to $66,000. When the prices were deflated by the consumer price index, the mean was $13,787.

The average home contained 1067 square feet on the first floor, and the additional space on upper floors and in basements averaged less than 200 square feet. The average house had a garage with one to two stalls, either attached or detached. The average age of the houses was about 30 years, although they ranged in age from new to eighty years old.

Noise monitoring was done at 27 locations during peak hours. However, because of the amount of undeveloped land or acreage near the highway, there were a limited number of houses affected by highway noise. Most of these had not sold since the highway was opened, so there were only seven observations where the noise level was above ambient. This is also due to the relatively low traffic volume on SR 512, an average daily traffic volume in 1976 of 9,300. There were, however, 95 sales on houses located southeast of the highway and thus possibly isolated from the town.

Table 7-1

Puyallup Variable Definitions

Variable Name	Definition
QUAL	Quality
AGE	Age
AREA1ST	First floor Area
AREAUP	Upper floor area
BSMTFIN	Finished basement area
BSMTUNF	Unfinished basement area
FINATTIC	Finished attic area
BATHS	Number of baths
ATTGAR	Attached garage area
CPORTST	Number of carport stalls
FRPL	Number of fireplaces
LOTAREA	Lot area
FAHW	Forced air or hot water heat
COND	Physical condition
FLCPT	Carpeted floors
BRICK	Brick
WDRF	Wood shake roof
INOISCON	Noise contour at time of sale
SE	Located on southeast side of highway
CONIM4	Sales in control area after opening of highway
CONTROL	Located in control area

TABLE 7-2

PUYALLUP STUDY AREA

HEDONIC REGRESSION WITH LPRICE AS THE DEPENDENT VARIABLE

AND MEASURED NOISE LEVELS

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTIC	COEFFICIENT EVALUATED AT MEAN PRICE
QUAL	0.1082681	0.01859	5.823	1877.917
AGE	-0.3859578D-02	0.00060	6.423	-66.945
AREA1ST	0.3749090D-03	0.00004	9.323	6.503
AREAUP	0.2501126D-03	0.00004	6.245	4.338
BSMTFIN	0.2206495D-03	0.00006	3.506	3.827
BSMTUNF	0.1314834D-03	0.00004	3.652	2.281
FINATTIC	0.1254016D-03	0.00007	1.673	2.175
BATHS	0.8053075D-01	0.02954	2.726	1396.811
ATTGAR	0.7363885D-04	0.00006	1.324	1.277
CPORTST	0.4008877D-01	0.01964	2.041	695.343
FRPL	0.4834855D-01	0.02133	2.267	838.609
LOTAREA	0.5703392D-05	0.00000	5.249	0.099
FAHW	0.7997988D-01	0.01942	4.119	1444.242
COND	-0.7187199D-02	0.00215	3.336	-124.662
D65	-0.8893640D-01	0.04948	1.797	
D66	-0.9676647D-01	0.04390	2.204	
D68	0.1238584	0.04139	2.993	
D69	0.2069764	0.04212	4.914	
D70	0.1967165	0.04644	4.236	
D71	0.1881290	0.04277	4.399	
D72	0.2261589	0.04130	5.476	
D73	0.2673219	0.04074	6.561	
D74	0.3734588	0.04036	9.254	
D75	0.4939764	0.03815	12.949	
D76	0.5092142	0.07261	7.013	
FLCPT	0.4464928D-01	0.02483	1.798	791.994
BRICK	0.5849995D-02	0.05104	0.140	101.766
WDRF	0.7768260D-01	0.04423	1.798	1401.127
INOISCON	-0.5693080D-01	0.05411	1.052	-987.469
SE	-0.1813454D-02	0.02822	0.063	-31.426
CONIM4	-0.7501531D-01	0.04349	1.725	-1253.541
CONTROL	0.5322046D-01	0.02537	2.098	948.118
(CONSTANT)	8.709432			

R SQUARE	0.68362
ADJUSTED R SQUARE	0.67103
STANDARD ERROR	0.23871

The variables on which there was data available were similar to those in Table 4-1, but with minor differences because of the different county. The variables actually used in the regression are defined in Table 7-1. Table 7-2 reports the results of a typical regression. The coefficients of the variables have the expected signs and magnitudes and bear the expected relationship to each other.

To study whether or not the highway had any generalized effects on properties in the area, several techniques were utilized. The coefficients of the time dummy variables could be used as before to develop a real estate price index for the study area. This index is reported in Table 7-3. A control index such as was used in the King County studies is needed to examine any differential effects. The only available index is based on the mean sales price for all houses in Pierce County. There are two possible problems with using such an index: it applies to a very large area with many different types of houses and by looking at the mean price there is no consideration given to possible changes in quality. Nonetheless, this index is also reported in Table 7-3. The Pierce County index seems to be much more volatile than the study area index, but they move somewhat together both before and after the highway was opened. The study area increased slightly more rapidly in the initial years of the highway, but by 1976 they had increased the same amount since the opening of the highway.

An alternative to the Pierce County index was to use a control area. The control area was still in Puyallup but was substantially removed from SR 512. There were 188 sales in this control area. Since this was too small a sample to develop a completely independent index, dummy variables were used to allow for differential effects in the two areas. One dummy variable allowed for differences in the control area both before and after the highway while a second captured any additional differences after the highway was opened. The coefficient of the first was positive and significant which is to be expected given the more central location of the control area. The second variable indicates that properties in the study area appreciated approximately seven percent more than in the control area, but because of the large standard error this was not statistically different from zero at the .05 level.

These two techniques indicate that the effects of the highway may have been positive but were not large. This coincides with the interview data where few of the residents indicated using SR 512 in commuting to work. Since the time savings for residents would thus be small, it is not surprising that the property value effects were not large.

A dummy variable representing houses lying southeast was included in the regression to see if the property values were hurt by not having direct access to downtown. The coefficient was extremely small and added virtually no explanatory power to the regression. The residents' concerns had no effects on property values. The possible adverse effects of noise could not be adequately addressed in this study area because of the small number of observations with noise above ambient. The coefficient of the noise variable was negative but was not significantly different from zero. This is not to state that there were no noise damages, but rather that this study area does not provide evidence on the issue.

Table 7-3

Puyallup Real Estate Price Indexes

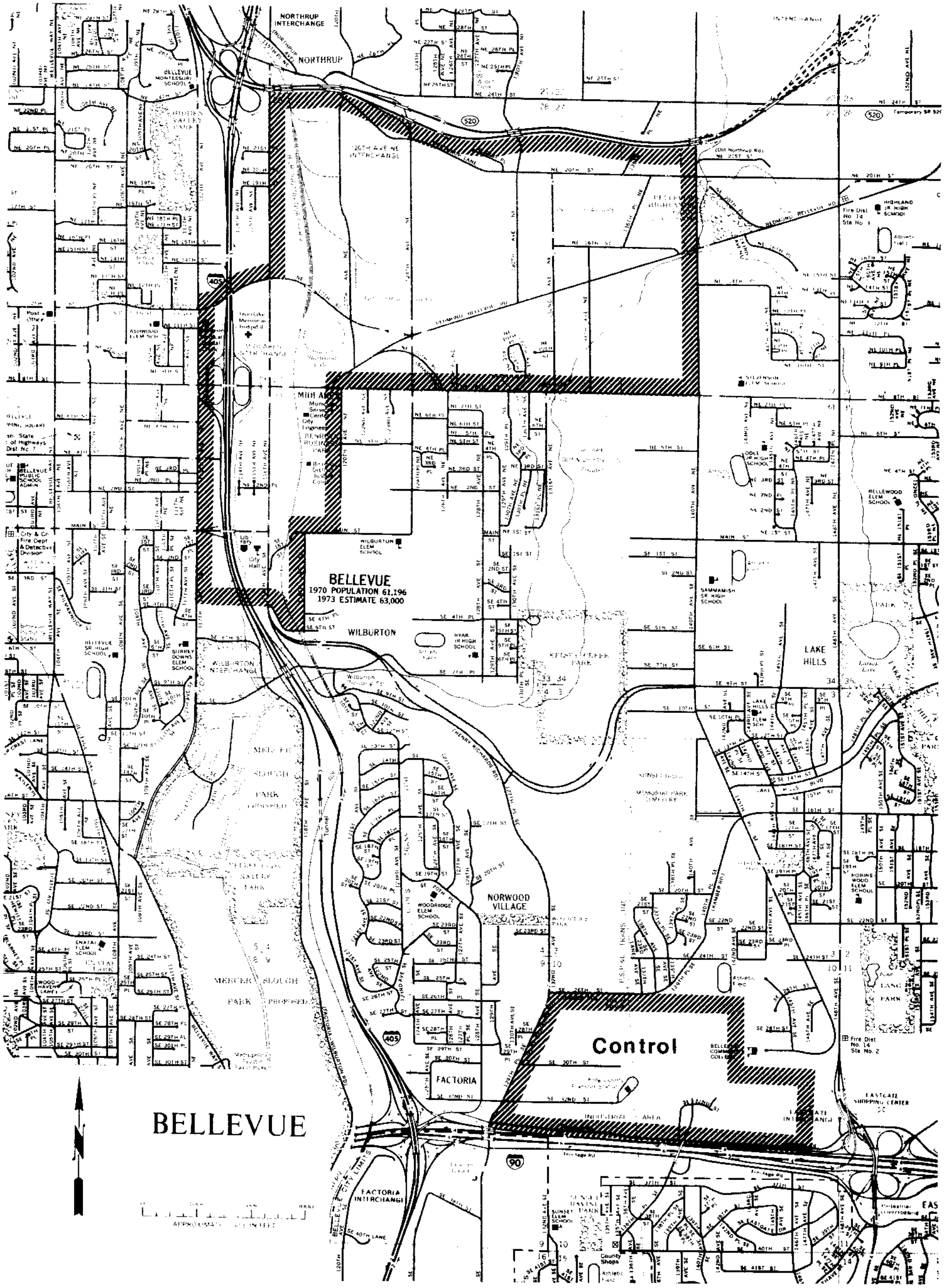
Year	Study Area Index	Pierce County Mean Sales Prices
65	.915	
66	.908	
67	1.000	1.006
68	1.132	1.099
69	1.230	1.246
70	1.217	1.127
71	1.207	1.115
72	1.254	1.305
73	1.306	1.445
74	1.453	1.501
75	1.639	1.647
76	1.664	1.840

Chapter Eight

Bellevue Commercial-Industrial Study Area

It was also desired to study the effects of a highway on property values in a commercial-industrial area. It was much more difficult to find acceptable study areas for this portion of the study for several reasons. First, commercial-industrial establishments generally have such definite transportation requirements that it is almost impossible to find such areas where there is not good access. This makes it quite difficult to find a study area that antedated the construction of a highway.

It is also necessary to control for the differences in the structures on the land to isolate the highway effects. With residential properties this was done by recording the various characteristics that individuals consider in making a home purchase and using hedonic regressions to isolate the desired effect. The same technique might be used with commercial-industrial properties, but the desired characteristics vary significantly with the types of businesses. This makes the specification of the hedonic equation considerably more difficult than in the residential case. In addition the data on characteristics are quite difficult to obtain because of confidentiality considerations. The selected alternative was to find an area where there was a mixture of commercial-industrial establishments and vacant land. This portion of the study could then examine trends in undeveloped land prices without considering structural characteristics. Interviews with established firms were also done to find the owner's perceptions


NORTHRUP INTERCHANGE
NORTHRUP
BELLEVUE MONTESSORI SCHOOL
520
405
MIDLAKES
BELLEVUE
1970 POPULATION 61,196
1973 ESTIMATE 63,000
WILBURTON
WILBURTON ELEM SCHOOL
SAMMAMISH SR HIGH SCHOOL
BELLEVUE SR HIGH SCHOOL
SURREY DOWNS ELEM SCHOOL
HYAK JR HIGH SCHOOL
LAKE HILLS
HIGHLAND JR HIGH SCHOOL
BELLEWOOD ELEM SCHOOL
NORWOOD VILLAGE
WOODRIDGE ELEM SCHOOL
ENATAI ELEM SCHOOL
ROBINSWOOD ELEM SCHOOL
MERCER SLOUGH PARK PROPOSED
Control
FACTORIA
FACTORIA INTERCHANGE
EASTGATE SHOPPING CENTER
SUNSET ELEM SCHOOL
County Shops
90
BELLEVUE CITY LIMITS
BELLEVUE
N

of the effect of the highway (see Chapter 11). However, this mixture of vacant and developed land is uncommon in commercial-industrial areas, making study site selection difficult.

A final problem is the lack of commercial-industrial real estate price indexes to serve as a control. For this reason an actual control area was necessary. Unfortunately, this area also had to have a mixture of undeveloped and developed land to be useful. It also had to be relatively close to the study area in terms of distance and character.

The study area which seemed to best meet these restrictive conditions was in Bellevue, east of I-405. This section of I-405 was opened in June, 1972, but there were already commercial and industrial establishments in the study area at this time. The irregularly shaped study area is roughly divided in two sections. The northern segment runs from Northrup Lane on the north to NE 8th Street on the south, and between 116th Avenue NE and 140th Avenue NE on the west and east respectively. A portion of the area continues south from NE 8th Street to SE 5th Street between 112th Avenue NE and 120th Avenue NE. These combined sections contain Benroya Business Park, the numerous automobile dealers 116th Avenue NE, and the extensive commercial development along the Bel-Red Road. Safeway and Coca-Cola are the two largest establishments in the area in terms of both area and dollar volume. Most of the manufacturing businesses are located in the northern part of the study area. Much of the northwest portion of the study area is served by several railroad sidings to the Burlington

Northern line. A substantial amount of vacant land remains throughout the area.

The control area selected was further south along I-90. This Interstate highway provides transportation access to the area, but there were no major changes in the highway during the period studied. The control area extends from I-90 on the south to SE 26th Street on the north, and from 128th Avenue SE to 148th Avenue SE on the west and east respectively. It is similar in character with small shopping centers, light industry, and vacant land.

Because of confidentiality restrictions, data on sale prices and dates were collected from the monthly publications of Monitor Real Estate Corporation of Seattle rather than the assessor's records. Monitor records all sales in King County for which the legally-required excise tax is paid. Sales are classified by type of zoning and vacant or nonvacant land. All sales of vacant land within the study and control areas between 1965 and 1977 inclusive were collected. This provided 268 observations. Zoning information was obtained from the Bellevue Planner's Office, and land areas and access information were obtained from assessor's maps. A majority of the land was zoned for either manufacturing or for retail-wholesale use, although there were three other general classifications that accounted for approximately 20 percent of the sales. There was a wide range of land areas from about 20,000 square feet to over 650,000 square feet.

The variables used in the regression are defined in Table 8-1. A majority of the variables were made amenable to regression analysis

Table 8-1

Bellevue Variable Definitions

Variable Name	Definitions
A1	Parcel size less than 50,000 sq. ft.
A2	Parcel size 50 - 100,000 sq. ft.
A3	Parcel size 100 - 200,000 sq. ft.
A4	Parcel size 200 - 300,000 sq. ft.
A5	Parcel size over 300,000 sq. ft.
FRONT	Number of feet fronting on street
ZPRO	Zoned for professional office building
ZRET	Zoned for retail establishments
ZOFF	Zoned for motor hotels, office, etc.
ZFAM	Zoned for residential use
CONAFT	Sale in control area after highway opened
CONBEF	Sale in control area before highway opened
ACCESS	Street access
RR	Railroad access
HWYDIST	Direct distance to highway
INTCGDIS	Street distance to interchange
D65 - D77	Dummy variables for year of sale
PRSQFT	Price per 1,000 square feet

TABLE 8-2

BELLEVUE STUDY AREA
HEDONIC REGRESSION WITH LPRSQFT AS THE DEPENDENT VARIABLE

VARIABLE	COEFFICIENT	STD ERROR	T-STATISTIC	COEFFICIENT EVALUATED AT MEAN PRICE
RR	0.1111541	0.24100	0.462	194.601
D65	-0.1234080	0.32796	0.377	
D66	0.3042025	0.29258	1.040	
D68	0.2500540	0.28466	0.879	
D69	0.6971990	0.27796	2.508	
D70	0.6724093	0.33948	1.981	
D71	0.6804917	0.33285	2.045	
D72	0.8410996	0.35307	2.382	
D73	0.1447019	0.33992	0.425	
D74	0.8825720	0.31100	2.838	
D75	0.9611871	0.37040	2.595	
D76	0.6170485	0.34933	1.766	
D77	1.013159	0.63635	1.592	
A2	-0.3761467	0.16652	2.259	-518.912
A3	-0.6868923	0.19782	3.472	-822.422
A4	-1.837649	0.33404	5.501	-1391.732
A5	-1.904377	0.45218	4.212	-1408.741
FRONT	0.6576240D-03	0.00032	2.071	1.089
ZPRO	-0.2713047	0.20969	1.294	-393.309
ZRET	0.8031570D-01	0.15699	0.512	138.425
ZOFF	-0.5999531	0.57154	1.050	-746.778
ZEAM	-0.4292865	0.29072	1.476	-577.719
CONAFT	-0.5408808	0.42473	1.274	-691.497
CONBEF	-0.3579018	0.29857	1.199	-497.990
ACCESS	0.3890166	0.22937	1.696	787.110
HWYDIST	-0.7271222D-02	0.00510	1.425	-12.036
INTCGDIS	0.2263358D-01	0.04668	0.485	37.464
(CONSTANT)	6.638967			

R SQUARE	0.34012
ADJUSTED R SQUARE ($\bar{R}^2$)	0.26588
STANDARD ERROR	1.01232

through conversion to dummy variables. Since the price per square foot tends to differ significantly for different sizes of parcels, dummy variables for different ranges of areas were included. Other dummy variables represented accessibility to streets, rail, and highway. The results of the regression are reported in Table 8-2. The dependent variable is the natural logarithm of the price per thousand square feet. All of the accessibility measures have coefficients with the expected signs. The price per square foot decreases with an increase in the parcel size as expected, and this relationship is the most statistically significant. The values of manufacturing zoning and retail-wholesale zoning are greater than other uses.

The number of observations in the control area was too small to develop a completely independent price index. Instead, dummy variables for the control area before and after the opening of I-405 were used. Land in the control area was of less value throughout the period studied than land in the study area, a result that would be expected given the proximity of the study area to downtown Bellevue. However, after the highway was opened, the differential became greater. Using the coefficients of the two control area dummy variables, it can be calculated as 16.7 percent appreciation due to the highway. It appears that the highway has had a positive effect on land values in the study area.

Chapter Nine

Highway Proximity and the Length of Time on the Market

The studies described previously have established that in some areas property values have been increased by highway access, but this has been partially offset by highway noise and possibly by other negative proximity effects within the area closest to the highway. The amount of this partial reduction has been quantified. It is possible that, in addition to this price effect, highway proximity might increase the average time on the real estate market for houses in the impact zone. Such a possibility was expressed as a fact by almost half of the residents of the impact zone who were interviewed. Such behavior, should it exist, might contradict the predictions of some theories of the optimal pricing of heterogeneous capital goods.

There is a significantly greater amount of time involved in the marketing of a heterogeneous capital good such as a house than there is for a homogeneous good such as pencils. This is precisely because of the heterogeneity. People with differing tastes in houses would be willing to pay different amounts for a particular house with a particular vector of characteristics. Thus when a person sells a house, a variety of offers are received. Because of information costs, these offers are not received simultaneously but rather are spread out over time. The individual is forced to select a price that maximizes the present value of the incomes from that house. By setting the price higher, the individual also increases the expected waiting time before the sale. The problem of selecting the optimal price to set (and thereby the optimal expected time on the market) has been considered by Gordon and Hynes (1970), Nichols (1970), and Karlin (1962). This study extends their work to include consideration of a comparison of the optimal waiting time for alternative assets.

If an individual markets his or her house, there exists a spectrum of potential offers, but these offers will be spread out over time. These potential offers can be characterized by a probability density function, f(p), representing the probability of receiving the alternative offers in a given time period. Corresponding to this function there is a cumulative density function, F(p), such that

$$F(p) = \int_{-\infty}^{p} f(p)\, dp. \tag{9.1}$$

This function represents the probability of obtaining a price that is less than or equal to p in that time period. Finally,

$$\pi = h(p) = 1 - F(p) \tag{9.2}$$

represents the probability of obtaining a price greater than or equal to p in the unit time period. Once the owner of a house sets a price p_o, then anyone whose potential offer was greater than or equal to p_o can obtain the house for p_o. Thus, h(p) provides the probabilities that the owner must consider in setting the optimal price.

If the owner sets a price p, he or she will receive p with probability h(p) in the first period. If the house is not sold in the first period, it may be sold in the second period with the same probability. But the price must be discounted to convert it to present value. The same logic applies to future periods. Thus the expected present value is

$$E(PV) = p\,h(p) + p\,h(p)\left(\frac{1 - h(p)}{1 + r}\right) + p\,h(p)\left(\frac{1 - h(p)}{1 + r}\right)^2 + \dots \qquad (9.3)$$

where r represents the opportunity cost of the unrealized funds in the form of interest foregone and depreciation incurred. This is a geometric series which converges to

$$E(PV) \to p\,h(p)\left(\frac{1 + r}{r + h(p)}\right). \qquad (9.4)$$

The owner can be assumed to maximize this expected present value.

Differentiating this series with respect to price yields a series which converges to

$$\frac{dE(PV)}{dp} = \frac{1 + r}{r + h(p)}\left[h(p) + ph'(p) - \frac{h'(p)\,h(p)}{r + h(p)}\right]. \qquad (9.5)$$

Setting this equal to zero and simplifying yields

$$p^* = \frac{h(p^*)\,[r + h(p^*)]}{-\,r\,h'(p)}, \qquad (9.6)$$

which can theoretically be solved for the optimal price. This optimal price also allows solving for the expected time on the market, E(T), using the equation

$$E(T) = \frac{1 - h(p^*)}{h(p^*)} \quad . \tag{9.7}$$

The effect of changes in the distribution of potential offers on the optimal expected waiting time is the important consideration for the purposes of this study. To simplify the exposition, this discussion will consider the offers to be distributed according to the continuous uniform distribution over a range from the minimum potential offer of p_o to the maximum of p_1. Such a distribution has a cumulative probability density function F(p) such that

$$F(p) = \begin{cases} 0 & \text{if } p \leq p_o \\ \dfrac{p - p_o}{p_1 - p_o} & \text{if } p_o < p < p_1 \\ 1 & \text{if } p \geq p_1 \end{cases} \quad , \tag{9.8}$$

and thus

$$\pi = h(p) = \begin{cases} 1 & \text{if } p \leq p_o \\ \dfrac{p_1 - p}{p_1 - p_o} & \text{if } p_o < p < p_1 \\ 0 & \text{if } p \geq p_1 \end{cases} \quad . \tag{9.9}$$

In this case equation (9.6) becomes

$$p^* = \frac{\left(\dfrac{p_1 - p^*}{p_1 - p_o}\right)\left[r + \dfrac{p_1 - p^*}{p_1 - p_o}\right]}{-r \quad \left(- \dfrac{1}{p_1 - p_o}\right)} \text{ for } p_o < p^* < p_1 . \tag{9.10}$$

If the boundaries of the distribution, p_o and p_1, are both increased or decreased by a factor α, the optimal price is also multiplied by the same factor α. This can be seen by solving equation (9.10) with p_o and p_1 changed to αP_o and αP_1. If this were not true, there would be money illusion in the model since doubling all the potential offers would not double the optimal price. In this situation individuals would change the optimal waiting time in response to an inflation where real prices were unaffected. Such an undesireable situation is avoided in this model.

The next question to be considered concerns the effect on the optimal price of an increase in the variance of the distribution of offers if the mean remains the same. The boundaries of the distribution are changed to $p_o - \alpha$ and $p_1 + \alpha$, and these values are entered in equation (9.10). The derivative of the optimal price with respect to α is

$$\frac{dp^*}{d\alpha} = \left(\frac{1}{p_1 - p_o + 2\alpha} - \frac{p_1 - p^* + \alpha}{2(p_1 - p_o + 2\alpha)^2}\right) [(p_1 + \alpha)(1 + r)$$

$$- (p_o - \alpha) r - p^*] + \frac{p_1 - p^* + \alpha}{p_1 - p_o + 2\alpha} (1 + 2r) > 0 \qquad (9.11)$$

where the fact that p^* is between the two boundaries has been used in evaluating the inequality. Thus, if the variance of the distribution rises without the mean being affected, then the optimal price and the optimal expected waiting period increase. Similar results could also be derived if the potential offers follow more complex distributions.

This theory was used to develop the hypothesis that the actual time on the market was unaffected by the distance to the highway.

This would imply that the potential offers on a house near the highway are proportionally reduced from the potential offers further back. The owners of houses in the impact zone are aware of the effect of the highway on the potential offers and thus adjust their asking price accordingly. The expected waiting time is unaffected. This hypothesis would be contradicted if the variance of the potential offers on a house in the impact zone was larger relative to other houses in the study area, or if the owners were systematically biased in their estimates of the effects of the highway on the potential offers.

To test this hypothesis, data were necessary on the length of time houses within an area studied were on the market. Such information was provided for the Kingsgate area by the Cumulative Street Index File, January 1974 through June 1976 issued by the Eastside Brokers Association. This publication by a multiple listing service provides information on all residential listings by member firms during the period indicated. This represents over eighty percent of the houses that were on the market in that area. All market listings on single-family residences within the study area were selected. Data were collected on the initial listing price, the selling price, the number of days on the market, the terms of the sale, the end date of the listing, and the status of the property. The status of the property referred to whether the house had been sold or withdrawn from the market by the owner; or if the listing had been inactive during the time period covered or had expired. The data provided 1,170 cases of which 64 were on houses within 600 feet of the highway. Of these

1,170 cases, 895 were sold, 169 expired, 81 were withdrawn, and 25 were inactive at the end of the dates covered.

The first tests concerned comparisons of the mean number of days on the market for different subgroups of the market. The results are reported in Table 9-1. Of those properties which sold, the ones close to the highway averaged about seventy days on the market, while those more removed averaged about 81 days. For properties which were not sold in the period covered, the number of days on the market averaged about 75 days for the impact area and about 96 days for the study area. The relationship in both these pairs runs counter to the beliefs expressed by many residents.

It is important to test whether or not the differences are significant. This can be done with a t-test comparing the two means. If the two populations have equal variances, the common variance can be estimated by

$$S^2 = \frac{(n_1 - 1)S_1^{\,2} + (n_2 - 1)\ S_2^{\,2}}{n_1 + n_2 - 2}\ . \tag{9.12}$$

The variance of the difference of the sample means is

$$S^2_{\Delta\ \bar{x}} = \frac{S^2}{n_1} + \frac{S^2}{n_2}\ . \tag{9.13}$$

The null hypothesis that the sample means are equal can then be tested using

$$t_{\Delta\bar{x}} = \frac{\bar{x}_1 - \bar{x}_2}{S_{\Delta\bar{x}}} \qquad (9.14)$$

which follows the t distribution with $n_1 + n_2 - 2$ degrees of freedom. If the calculated t-value exceeds the tabled value for a particular level of confidence, the null hypothesis can be rejected. It can be tested whether or not the populations have equal variances using

$$F = \frac{\text{larger } S^2}{\text{smaller } S^2} \qquad (9.15)$$

Which is distributed $F\ (n_{larger} - 1,\ n_{smaller} - 1)$.

Using these formulas to test the significance of the difference in the mean number of days on the market for houses sold in the impact area and the study area yields a t-statistic of .898 with 672 degrees of freedom, so the null hypothesis cannot be rejected. For a comparison of the means for houses which did not sell the t-statistic is .819 with 233 degrees of freedom, so the null hypothesis cannot be rejected in this case either. The assumption of common variance is supported in the cases of houses sold and not sold by the respective calculated F-statistics of 1.161 with 640 and 32 degrees of freedom and 1.287 with 220 and 13 degrees of freedom. Thus, statistically there is no difference in the number of days on the market for houses next to the highway compared with houses more removed from the highway.

Table 9-1

Statistics on Days on the Market for Various Subgroups

Population	Mean	Variance	Number of Cases
All properties on the market	84.177	5753.848	909
Properties which sold	80.352	4767.445	674
Impact area	69.667	2188.292	33
Study area	80.902	4897.660	641
Properties which did not sell	95.149	8452.355	235
Impact area	74.929	848.225	14
Study area	96.430	8912.445	221

Table 9-2

Statistics on Price Reductions for Various Subgroups

Population	Mean	Variance	Number of Cases
All properties which sold	314.532	2,017,837.296	895
Impact area	587.200	1,077,936.068	45
Study area	300.096	2,064,773.573	850

The reduction in the final selling price from the initial asking price is reported in Table 9-2. The average reduction is larger for those houses next to the highway, although the variance in the reductions is very large. Because of this one cannot reject at the 90 percent level of confidence the hypothesis of equal means. The calculated statistic is 1.322 with 893 degrees of freedom. The assumption of common variance is again reasonable with F=1.384 (849,44). Even if the difference in the reductions was statistically significant, this would simply indicate that price effects studied previously were capturing the negative effects as owners of houses in the impact zone quickly revised their asking prices downward.

An alternative method of analyzing the same relationships was to calculate the correlation coefficients. These results are reported in Table 9-3. The correlation coefficients are extremely low for the three relationships discussed previously. The significance of the relationships can be tested with the statistic

$$t = r \left(\frac{N-2}{1-r^2} \right)^{\frac{1}{2}} \tag{9.16}$$

where r is the correlation coefficient and N is the number of cases. If the true coefficient is 0 then the sampling distribution of r is symmetric, and equation (9.16) is distributed t_{N-2}. The significances of the various coefficients are also reported in Table 9-3. The hypothesis that the correlation coefficient of location relative to the highway with days on the market is zero cannot be rejected even at a 90 percent confidence level. The same hypothesis for the correlation of location with price reductions cannot be rejected at a 95 percent confidence level. It is interesting to note that DAYS is significantly correlated with REDUCE, but neither of these is correlated with location.

In the theory concerning the optimal expected waiting time, it was hypothesized that once an individual decided to sell a house, that house was on the market until sold. With the data that were used, it was also possible that a house was withdrawn from the market or not sold by a member of the multiple listing service within the period reported. For these reasons it was necessary to examine whether or not highway proximity influenced the proportion of the listings that were not sold. The results are also reported in Table 9-3. The correlation coefficient of the two variables is quite low but indicates a slight tendency for more houses near the highway to remain unsold. However, the t-test reveals that one cannot reject the hypothesis of zero correlation at a 90 percent level of confidence. Thus, statistically the probability of a house remaining unsold is unrelated to the distance from the highway. A chi-square test for association of these two variables also shows that one cannot reject the hypothesis of no association. The chi-square value is 1.09883 with one degree of freedom shows that the hypothesis of no association cannot be rejected even at the 80 percent confidence level.

Further tests of association show that there is no relationship between the distance to the highway and the terms of the sale or the date of the sale. There is strong association between the length of time on the market and the terms of the eventual sale since the less

Table 9-3

Correlation Coefficients

Houses that Sold

	IM with DAYS	IM with REDUCE	DAYS with REDUCE
Correlation Coefficients	-.0351	.0442	-.1552
Cases	674	895	674
Significance	.181	.093	.001

Houses That Did Not Sell

	IM with DAYS
Correlation Coefficient	-.0555
Cases	235
Significance	.199

Total Population

	IM with STAT
Correlation Coefficient	.0351
Cases	1170
Significance	.115

Variables: IM = 0 if house is in study area, 1 if house is in impact area.
DAYS = number of days on the market
REDUCE = initial price - sales price
STAT = 0 if house sold, 1 if house did not sell

desirable terms are generally used after the house has remained on the market for a period of time. But the distance to the highway does not affect this choice of terms. There are also cycles in the real estate market, but the distance to the highway does not affect any cyclical movements. The houses in the impact zone do not seem to be more strongly hit by a downturn, although data over a longer period of time would provide a more powerful test of this theory.

All evidence points to any negative effects of the highway on sales of adjoining properties taking the form of price changes. Thus, the effects measured in the previous chapters exhaust the adverse effects on properties. The theory hypothesized in this chapter is not refuted by any of the available evidence.

Chapter Ten

Residential Interviews

Another phase of the study involved personal interviews with the residents to discover their perceptions of the beneficial and adverse effects of having a major highway located nearby. The effects that they perceived were then compared with the effects revealed by the real estate market as presented earlier in this report.

These interviews were conducted in person by a team of interviewers. This method was selected in order to obtain the desired high return rate and insure hearing the opinions of those residents who were disgruntled with the highway. A test interview form was developed and pairs of interviewers checked to see that the questions were understood in preliminary interviews and that representative responses were included in the coding. After slight modifications of the form were made in response to these test interviews, the interviews were carried out by individual interviewers. It was desired to have any residents present who commute to work and where possible to have both husband and wife present. For these reasons a majority of the interviews were conducted on weekends and at night. There was an almost even split between the number of men and women interviewed, although both were present at only about 15% of the interviews. A sample of the forms that were used is included in Appendix A.

The residents to be interviewed were selected by two methods. The study attempted to obtain interviews with at least one adult occupant of each house which abutted the highway. This saturated sampling was chosen since there was special interest in the perception of adverse effects by residents in close proximity to the highway. To obtain such complete sampling, as many as five return trips at various times were used in order to find the occupants at home. The second part of the interviews was with the occupants of houses in the study area but further back from the highway. Sampling here was based on a proportional, stratified random sample. The houses were stratified according to the plat in which they were located. This provided a sampling that represented houses at different distances from the highway and in various price ranges.

Kingsgate Area

The first area where interviews were conducted was Kingsgate along I-405. Interviews were held with 114 people living in abutting houses. Only twelve abutting households were not interviewed: an interview was refused at six and six were temporarily unoccupied. A sampling of households further back yielded 126 additional interviews.

The first questions in the interview were demographic in nature and were used to establish the general characteristics of the population sampled and validate the representativeness of the sample by comparison with the 1970 Population Census for that area. Both men and women were evenly split between the 20 to 35 and the 35 to 60 age brackets. For the men this coincided very well with the census data for Tracts 219 and 220 in King County. For women this represented a somewhat older distribution than the census. The occupations of adults in the households reveal the nature of the area. Almost one-fourth of those employed were in professional and technical positions and another one-fourth had managerial and administrative jobs. Clerical and sales workers made up approximately 17 and 14% respectively of those employed. The remaining workers were about evenly distributed among the remaining categories. This agrees quite well with the Census data except that the managerial and administrative category was more heavily represented in this survey. In the six years between the Census and the interviews there was considerable construction of the more expensive homes, so that it is probable that the characteristics of the population have gradually been changing as well. As far as the locations of the jobs, 45.7% worked west of Lake Washington, 40% on the east side of the lake, and 14.4% in more distant locations, most frequently Everett. Finally, 94.2% of the families owned their own home, while the Census found that 90% of the families in those Census tracts did. Thus, the interviews seem quite representative of the young, middle to upper-middle class residents of the neighborhood.

The residents in the impact zone next to the highway were almost identical with the total sample as far as location of work and ownership of the houses. The impact zone had a somewhat older population distribution. This might seem surprising, but it is probably accounted for by the fact that many of the homes which are now next to the highway were constructed before many of those further back. Thus the impact-zone residents may be older simply because they have been living in the houses longer, while younger people have found the new homes more available. One cannot safely explain the age difference by the highway. Another difference between the impact and the study area is that the impact area has substantially more professional and technical workers and clerical workers, but less managerial and administrative workers. There seems to be no particular pattern of occupations between the two areas, and it is interesting to note that the impact area does not seem to be dominated by lower-income or blue-collar workers.

The next group of questions sought to discover the residents' reasons for choosing the neighborhood and the particular house in which they lived, and their expectations about moving. As expected there were a variety of reasons given for selecting the neighborhood. Approximately 12% indicated that they selected the neighborhood specifically because of the highway accessibility. A variety of other reasons were given more or less frequently. It is interesting to compare answers within the impact zone with those in the total sample. Surprisingly, low price was mentioned less frequently in the impact area in discussing both the neighborhood and the specific dwelling. Later questions revealed that the residents felt that highway proximity lowered property values, but no more mentioned low price in the impact zone than in the study area as influencing their decision. Significantly more mentioned availability of housing in the impact area, and fewer mentioned the nearness of rural areas. Other differences were minor. Slightly more people said they intended to move within the next year in the study area than in the impact area.

However, four families in the impact area gave adverse highway effects as their reason for moving while no one in the study area mentioned that reason.

The rest of the interview form relates directly to the parts of the study discussed earlier in this report. It was designed to discover people's perceptions of the beneficial and adverse effects of the highway as they relate to the residence itself.

The first questions of this part referred to the awareness of highway benefits. The distribution of responses to the general question, "Are there benefits to you from having a highway nearby?", was quite revealing. In the impact area the interviewers explained that this question referred to benefits from having the highway in the area and not necessarily from having it within 600 feet. In spite of this clarification, impact zone residents reported benefits less frequently than those living in the study zone. In the impact zone 82.5% felt there were benefits, which seems a substantial proportion until it is compared with the study zone where 99.2 percent mentioned benefits. Since the locations of work and distance to highway access did not differ substantially between the areas, it appears that the same benefits were present for the two groups. Yet the adverse effects in the impact zone may have been preventing approximately one-fifth of those interviewed from being aware of such benefits. (See the Kingsgate results in the Appendix).

For the entire sample, 64.2 percent of those interviewed felt that the highway offered them reduced travel time. Even more, 82.5%, felt that the highway provided easier accessibility to and from the area. Finally, five percent mentioned some other benefit such as not having as many neighbors if the house abutted the highway. Another question pursued the time savings benefits. Of those who felt they saved time because of the highway, the average savings expressed was just under five hours per week saved compared with the situation if I-405 had not been built. When the entire sample was included this was reduced to an average of approximately three hours per week. As expected, on this question over one-third of those interviewed were unable to provide an estimate. A t-test was used to see if there were any significant differences in the time-savings answers given by men and given by women. It was found that when the interview was with one adult, sex made no significant difference. However, when both the husband and wife were present, their answers indicated significantly more time-savings than when an individual was interviewed. This difference was significant at the .05 level. The interviewers felt that in the exchange when two people were present, the estimates were raised. Of course, this hypothesis is not testable with the current data, but additional testing might be of interest. The estimates of time-savings seem high, and it may be possible that the residents were considering savings due to the bridges over Lake Washington as well as I-405. No independent estimates of time-savings were available.

The next questions in the interview concerned perceived adverse effects. The questioning was divided into two parts. First, people were asked which adverse effects, if any, they noticed, and then they ranked the importance of these effects. For this part of the interview no suggestions of possible effects were made by the interviewers. Secondly, the respondents were asked to evaluate the importance of effects suggested by the interviewer. Questioning here concerned the effects both inside and outside the dwelling.

The results from the first part are reported for the entire sample in Table 10-1. Noise was the one adverse effect mentioned extensively. Within the impact zone approximately three-fourths of those interviewed cited noise as the most important adverse effect. Those further removed from the highway in the study area still mentioned noise in one-fourth of the cases. Air pollution was the other problem mentioned with the next greatest frequency, but noise was mentioned almost ten times as often.

The questions to this point only revealed which effects were mentioned and not the relative severity of the problems. The next part of the interviews sought relative evaluations of the different effects. The results are reported in Table 10-2. The first point about these responses is that the highway seems to have few adverse effects for those residents more than six hundred feet from the highway, which agrees with the noise monitoring results reported earlier. Only one respondent found any of the effects annoying inside the home. Less than 16% even noticed the noise, and they did not find it annoying. Outside the home the results were comparable except for noise where about five percent now found the noise annoying. Thus it appears that the measure of the adverse effects used earlier in this study coincides fairly well with the responses.

The responses in the impact zone were perhaps surprising in that many people did not find the effects annoying. Inside the houses only about five percent of the residents found effects other than noise to be annoying or objectionable. Within the house 16.7 percent found the

TABLE 10-1

Adverse Effects Voluntarily Mentioned and Ranked in the Total Sample

	Number of People Giving Ranking				
	1	2	3	4	5
Noise	117(48.7%)	1(0.4%)			
Air Pollution	5(2.1%)	8(3.3%)			
Lights					
Vibration	3(1.2%)	1(0.4%)	2(0.4%)		
Visual Effects	4(1.7%)	2(0.4%)		1(0.4%)	
Other1/	28(11.7%)	3(1.2%)	1(0.4%)		1(0.4%)

1/ Most of the other effects mentioned involved issues that were specific to this section of highway, such as the existence of a gravel pit that was an attraction for children. Two families felt that the highway separated them from friends or relatives living on the other side which is an effect that might be present on any segment of highway.

Table 10-2

RESPONSES IN THE IMPACT ZONE (within 600 feet of the highway)

How would you describe the overall effect of these highway disturbances?

A. Inside your home:

	Objectionable (4)	Annoying (3)	Noticeable But not Annoying (2)	Not Noticeable (1)
Noise..........	4(3.5%)	19(16.7%)	52(45.6%)	39(34.2%)
Air Pollution...	3(2.6%)	4(3.5%)	8(7.0%)	99(86.9%)
Lights.........			3(2.6%)	111(97.3%)
Vibration.......	2(1.8%)	3(2.6%)	4(3.5%)	105(92.1%)
Visual Effects..	2(1.8%)	3(2.6%)	5(4.4%)	104(91.2%)

B. Outside your home:

	Objectionable (4)	Annoying (3)	Noticeable But not Annoying (2)	Not Noticeable (1)
Noise..........	25(21.9%)	15(13.2%)	47(41.2%)	27(23.7%)
Air Pollution...	5(4.4%)	3(2.6%)	10(8.8%)	96(84.2%)
Lights.........			4(3.5%)	110(96.5%)
Vibration.......	2(1.8%)	3(2.6%)	5(4.4%)	104(91.2%)
Visual Effects..	2(1.8%)	3(2.6%)	5(4.4%)	104(91.2%)

TABLE 10-2 (Cont'd)

RESPONSES IN THE STUDY ZONE (more than 600 feet from the highway)

How would you describe the overall effect of these highway disturbances?

A. Inside your home:

	Objectionable (4)	Annoying (3)	Noticeable But Not Annoying (2)	Not Noticeable (1)
Noise............		1(0.8%)	20(15.9%)	105(83.4%)
Air Pollution....		1(0.8%)		125(99.2%)
Lights...........			1(0.8%)	125(99.2%)
Vibration........		1(0.8%)		125(99.2%)
Visual Effects...		1(0.8%)		125(99.2%)

B. Outside your home:

	Objectionable (4)	Annoying (3)	Noticeable But Not Annoying (2)	Not Noticeable (1)
Noise...........	1(0.8%)	6(4.8%)	33(26.2%)	86(68.3%)
Air Pollution...		1(0.8%)	1(0.8%)	124(98.5%)
Lights..........			1(0.8%)	125(99.2%)
Vibration.......		1(0.8%)		125(99.2%)
Visual Effects..		1(0.8%)		125(99.2%)

noise annoying and 3.5 percent found it objectionable. The most respondents found the effects other than noise 'not noticeable' and noise 'noticeable but not annoying'. Outside the home the effects were more important. The noise was annoying or objectionable to 35.1 percent of those interviewed, and seven percent felt that way about air pollution. The other effects were perceived to be the same as indoors.

Residents' evaluations of these adverse effects were compared with the peak hour L_{10} noise readings described earlier in the report. Cross tabulations of the inside noise ratings and outside noise ratings with the L_{10} readings are provided in Tables 10-3 and 10-4. It appears that there is a strong relationship between perceived and actual noise levels. In fact, the correlation coefficient between the inside the house rating and the measured noise level is .5302, and the correlation coefficient between perceived noise outside the house and measured noise levels is .5512. One can easily reject the hypothesis of no correlation using a t-test. Of course, there is less than perfect correlation because of the variation in individual's responses, but the high correlation indicates that L_{10} is an adequate approximation of the average human perception of noise for broad qualitative assessments of community noise levels. Peceptions of other adverse highway effects are also correlated with the noise readings, but not as highly. Since these other effects were considered important much less frequently than noise, the noise variables in the earlier regressions were predominantly measuring the effects of noise.

Table 10-3

CROSSTABULATION OF MEASURED AND PERCEIVED NOISE INSIDE HOUSES

	COUNT ROW PCT COL PCT TOT PCT	Interview evaluation of noise inside the house no response	 not noticeable	 noticeable not annoy	 annoying	 objecti-onable	ROW TOTAL
NOISECON, peak hour L_{10} noise reading	below 55 dBA	3 2.1 75.0 1.3	113 77.4 80.7 47.1	29 19.9 40.3 12.1	1 0.7 5.0 0.4	0 0.0 0.0 0.0	146 60.8
	55-57.5	1 9.1 25.0 0.4	4 36.4 2.9 1.7	5 45.5 6.9 2.1	1 9.1 5.0 0.4	0 0.0 0.0 0.0	11 4.6
	57.5-60	0 0.0 0.0 0.0	3 21.4 2.1 1.3	9 64.3 12.5 3.8	2 14.3 10.0 0.8	0 0.0 0.0 0.0	14 5.8
	60-62.5	0 0.0 0.0 0.0	8 44.4 5.7 3.3	7 38.9 9.7 2.9	3 16.7 15.0 1.3	0 0.0 0.0 0.0	18 7.5
	62.5-65	0 0.0 0.0 0.0	9 22.0 6.4 3.8	17 41.5 23.6 7.1	12 29.3 60.0 5.0	3 7.3 75.0 1.3	41 17.1
	65-67.5	0 0.0 0.0 0.0	3 37.5 2.1 1.3	3 37.5 4.2 1.3	1 12.5 5.0 0.4	1 12.5 25.0 0.4	8 3.3
	67.5-70	0 0.0 0.0 0.0	0 0.0 0.0 0.0	1 100.0 1.4 0.4	0 0.0 0.0 0.0	0 0.0 0.0 0.0	1 0.4
	70-72.5	0 0.0 0.0 0.0	0 0.0 0.0 0.0	1 100.0 1.4 0.4	0 0.0 0.0 0.0	0 0.0 0.0 0.0	1 0.4
	COLUMN TOTAL	4 1.7	140 58.3	72 30.0	20 8.3	4 1.7	240 100.0

Table 10-4

CROSSTABULATION OF MEASURED AND PERCEIVED NOISE OUTSIDE HOUSES

	COUNT ROW PCT COL PCT TOT PCT	Interview evaluation of noise outside the house no response	 not noticeable	 noticeable not annoy	 annoying	 objectionable	ROW TOTAL
NOISECON, peak hour L_{10} noise reading	below 55dBA	3	90	45	7	1	146
		2.1	61.6	30.8	4.8	0.7	60.8
		75.0	82.6	56.3	33.3	3.8	
		1.3	37.5	18.8	2.9	0.4	
	55-57.5	1	3	5	2	0	11
		9.1	27.3	45.5	28.2	0.0	4.6
		25.0	2.8	6.3	9.5	0.0	
		0.4	1.3	2.1	0.8	0.0	
	57.5-60	0	1	10	1	2	14
		0.0	7.1	71.4	7.1	14.3	5.8
		0.0	0.9	12.5	4.8	7.7	
		0.0	0.4	4.2	0.4	0.8	
	60-62.5	0	6	9	1	2	18
		0.0	33.3	50.0	5.6	11.1	7.5
		0.0	5.5	11.3	4.8	7.7	
		0.0	2.5	3.8	0.4	0.8	
	62.5-65	0	7	6	9	19	41
		0.0	17.1	14.6	22.0	46.3	17.1
		0.0	6.4	7.5	42.9	73.1	
		0.0	2.9	2.5	3.8	7.9	
	65-67.5	0	2	4	1	1	8
		0.0	25.0	50.0	12.5	12.5	3.3
		0.0	1.8	5.0	4.8	3.8	
		0.0	0.8	1.7	0.4	0.4	
	67.5-70	0	0	1	0	0	1
		0.0	0.0	100.0	0.0	0.0	0.4
		0.0	0.0	1.3	0.0	0.0	
		0.0	0.0	0.4	0.0	0.0	
	70-72.5	0	0	0	0	1	1
		0.0	0.0	0.0	0.0	100.0	0.4
		0.0	0.0	0.0	0.0	3.8	
		0.0	0.0	0.0	0.0	0.4	
	COLUMN TOTAL	4	109	80	21	26	240
		1.7	45.4	33.3	8.8	10.8	100.0

There was no statistically significant difference in the evaluations of adverse effects between men, women, and couples. It is interesting to note that in the more-removed study zone 64.3 percent of the houses were vacant during work hours on weekdays, but in the impact zone only 45.6 percent were vacant then. Thus the noise does not seem to cause people to be away from home more. Most people found the highway effects most annoying during the morning and evening rush hours, although some considered the period from 8 p.m. to midnight to be the worst.

The interviews then had the residents evaluate the beneficial and adverse effects together to find an overall rating of the highway's effect on their living conditions. The results for the different groups are reported in Table 10-5. For the entire sample the median and the mean of the responses were in the category 'good'. In the study area the most common response was 'very good', while the mean was half way between 'very good' and 'good'. In the impact area the most common response was 'good', but the mean was between 'good' and 'neutral'. The relationships between measured noise level and overall rating are revealed in Table 10-6. There is a statistically significant correlation between these two variables with a coefficient of .5676, so noise is an important factor in people's evaluation of the highway. It is of special interest to note that those people who bought their houses without knowing of the plans for the highway rated the highway significantly worse ("bad" was the most frequently given answer) than those people in the impact zone who bought their houses knowing of the plans.

TABLE 10-5

Residents' Overall Rating of the Freeway on Living Conditions

	VERY GOOD	GOOD	NEUTRAL	BAD	VERY BAD
Study Zone	62(49.2%)	52(41.3%)	11(8.7%)	1(0.8%)	
Impact Zone	11(9.6%)	47(41.2%)	33(28.9%)	21(18.4%)	2(1.8%)
Total Sample	73(30.4%)	99(41.3%)	44(18.3%)	22(9.2%)	2(.8%)

The part of the interviews which related most closely to the main body of this research concerned the perceived effects of the highway on property values. In the study zone, 46.8% felt that the highway had increased their property values compared with what they felt would have happened if the highway had not been constructed. No effect was expressed by 37.3%, while less than 2% felt that property values had been decreased by the highway. In the impact zone, 36% felt values had been hurt, 31.6% thought there was no effect, and only 13.2% thought they had increased. These results are summarized in Table 10-7.

Next the residents were asked if they could estimate the dollar value of these property value effects. Only about two-thirds expressed their opinions, but this was a high enough response rate to allow some generalizations. In the previous chapters multiple regression techniques were used to separate the value of a house into the value of its various attributes, one of which was noise. In the interviews the residents attempted to estimate the effect of noise if all the other attributes remained the same. Thus a regression with one noise variable for the interview data is similar to the earlier hedonic regressions. The results when the residents' estimates of the effect of the highway on property values were regressed on the noise variable are reported in Table 10-8. This coefficient is almost twice as large as the one estimated from market data earlier in the study. The residents' estimates of highway-induced property value changes included both adverse and beneficial effects while the hedonic coefficient did not. Thus the residents believed that the damages were more than twice as large as those found in actual sales (see Chapter 4).

This indicates that in evaluating highway impacts it is important to consider not only the anticipated actual effects on property values, but also the anticipated perceptions of those effects.

The final question in the interviews, other than certain questions used in specifying the earlier hedonic regressions, brought together all the issues discussed earlier in the interview. The respondents were asked if, in light of the beneficial and adverse effects as well as the property value influences of the highway, they would again choose to live as close to a major highway. It is interesting to note that even in the impact zone within 600 feet of the highway 55.3% of these interviewed answered that they would make the same choice again and 11.4% said they might. In the study zone more than 600 feet from the highway 68.8% answered 'yes', and 9.6% responded 'maybe'. Thus, even in the impact zone, a majority of the respondents would again make the same locational choice. This is not to deny that there is a correlation between negative responses and the measured noise levels. The correlation coefficient is .3564. But the negative responses were not nearly as common in the impact zone as might have been anticipated.

Table 10-6

CROSSTABULATIONS OF OVERALL HIGHWAY RATING AND MEASURED NOISE LEVEL

COUNT / ROW PCT / COL PCT / TOT PCT	OVERALL RATING: no response	very good	good	neutral	bad	very bad	ROW TOTAL
NOISECON							
below 55 dBA	1	65	64	14	2	0	146
	0.7	44.5	43.8	9.6	1.4	0.0	60.8
	100.0	89.0	65.3	31.8	9.1	0.0	
	0.4	27.1	26.7	5.8	0.8	0.0	
55-57.5	0	1	6	4	0	0	11
	0.0	9.1	54.5	36.4	0.0	0.0	4.6
	0.0	1.4	6.1	9.1	0.0	0.0	
	0.0	0.4	2.5	1.7	0.0	0.0	
57.5-60	0	3	4	5	2	0	14
	0.0	21.4	28.6	35.7	14.3	0.0	5.8
	0.0	4.1	4.1	11.4	9.1	0.0	
	0.0	1.3	1.7	2.1	0.8	0.0	
60-62.5	0	3	9	3	3	0	18
	0.0	16.7	50.0	16.7	16.7	0.0	7.5
	0.0	4.1	9.2	6.8	13.6	0.0	
	0.0	1.3	3.8	1.3	1.3	0.0	
62.5-65	0	1	12	14	12	2	41
	0.0	2.4	29.3	34.1	29.3	4.9	17.1
	0.0	1.4	12.2	31.8	54.5	100.0	
	0.0	0.4	5.0	5.8	5.0	0.8	
65-67.5	0	0	3	4	1	0	8
	0.0	0.0	37.5	50.0	12.5	0.0	3.3
	0.0	0.0	3.1	9.1	4.5	0.0	
	0.0	0.0	1.3	1.7	0.4	0.0	
67.5-70	0	0	0	0	1	0	1
	0.0	0.0	0.0	0.0	100.0	0.0	0.4
	0.0	0.0	0.0	0.0	4.5	0.0	
	0.0	0.0	0.0	0.0	0.4	0.0	
70-72.5	0	0	0	0	1	0	1
	0.0	0.0	0.0	0.0	100.0	0.0	0.4
	0.0	0.0	0.0	0.0	4.5	0.0	
	0.0	0.0	0.0	0.0	0.4	0.0	
COLUMN TOTAL	1	73	98	44	22	2	240
	0.4	30.4	40.8	18.3	9.2	0.8	100.0

TABLE 10-7

Responses on the Effects of the Highway on Property Values

	Increased	Decreased	No Effect	Uncertain
Study Zone	59(46.8%)	2(1.6%)	47(37.3%)	18(14.3%)
Impact Zone	15(13.2%)	41(36.0%)	36(31.6%)	22(19.3%)
Total Sample	74(30.8%)	43(17.9%)	83(34.6%)	40(16.7%)

The interviews showed that in many respects the residents' perceptions of the highway effects coincided closely with measured levels of those effects. Most people were aware of both the benefits and costs that the highway bestowed on them. The one exception to this appeared to be that those in proximity to the highway were not as aware of the highway benefits as those living further back. The one area where perceived and actual effects diverged substantially was the property value effects of the highway. People felt that their property values were decreased considerably more by noise than was actually the case.

TABLE 10-8

Regression with Perceived Property Value Effects
(in Thousands of Dollars)
of the Highway as the Dependent Variable

Variable	Coefficient	Std. Error	T-statistic
INOISE	-0.4939361	0.09614	5.1384
(constant)	0.8255008		
R-Square	0.09984		
Adjusted R-Square ($\bar{R}^2$)	0.09606		

PUYALLUP AREA

Interviews were also carried out in Puyallup to see if the residents' attitudes were different when a highway was built in a small town setting. As explained in Chapter Seven, it was anticipated that the impact of the highway, both beneficial and adverse, would be less than in the other study areas because the highway is not often used by residents for commuting to work and relatively few houses are immediately adjacent to the highway.

The interviews were carried out in the same manner as in Kingsgate, and the sampling procedures were similar. A total of 114 interviews were done. Since houses near the highway were heavily sampled, 46 of the interviews were at houses where the highway noise was above the ambient level. The average distance from the highway was approximately 900 feet with a range from abutting to 4,700 feet from the highway. The results are reported in absolute and percentage terms in the appendix.

The results differed from those in Kingsgate in several respects but also validated other conclusions. There were differences in the population being sampled. The residents are generally older than in Kingsgate with the average age of adults being 42 years. The proportion of people in the professional-technical occupation category was slightly smaller than in Kingsgate and the proportion in the managerial category was significantly smaller. A much higher percentage of the people were retired, and of those working proportionally more were craftsmen. While 87 percent of the people owned their own home, this was a lower figure than in Kingsgate.

The locations of employment are useful in predicting how many of those interviewed would use SR 512 for commuting. Approximately 38.7 percent of those who worked were employed in the Puyallup-Sumner area, 27.4 percent in Tacoma, and 21.8 percent in the Seattle-Kent area. Only 6.5 percent of those interviewed worked south of Tacoma or on the Olympic Peninsula. This small percentage represents the people who would be most likely to use SR 512. This result is supported by the fact that less than 2 percent of the people said that highway accessibility had affected their location choice. On the other hand, significantly more people said they planned to move within the next year, and 4.6 percent said that adverse highway effects were the cause of this.

Perception of benefits from the highway was much less frequent in Puyallup with only about half of the people acknowledging such effects. Easier accessibility was the most commonly sited benefit, while only about one-fourth of the people felt they achieved time-savings because of the highway. Those that did feel there were time-savings estimated these savings to be between one and two hours a week, on average.

When asked about possible adverse effects of the highway, the respondents wholeheartedly agreed with Kingsgate residents that the most inportant problem was noise. Over 30 percent of those interviewed felt that noise was the primary problem, and frequently it was the only problem mentioned. A small number of people mentioned air pollution or vibration. Of the problems which came under the "other" category, the most common complaint (10.1 percent) was the loss of farm land due to the highway. A few people also mentioned drainage problems caused by the highway and local traffic generated by the highway. It is interesting that no one mentioned being separated from downtown by the highway, yet this was a frequently voiced concern before and during construction. The people being interviewed confirmed the noise results when they were asked to give specific ratings for the various adverse effects. Almost 100 percent indicated that all effects other than noise were "not noticeable" both outside and inside the house. However, noise outside the house and inside the house was noticeable or worse to approximately one-fourth of those interviewed. Outside the house 10 percent found it objectionable, while 6.4 found it annoying. Inside the house 4.6 percent said highway noise was "objectionable" and 3.7 reported it to be annoying. These noise effects were found to be most annoying during the late night and early morning hours. A few people found the noise annoying during the evening rush hour, but not nearly as many as in Kingsgate. The probable reason that the rush hours were viewed as less of a problem was that there is less commuting traffic on SR 512 than I-405.

When the residents were asked to give an overall evaluation of the highway, the ratings were lower than in the previous interviews. A majority of the residents felt that the effect was either neutral, bad, or very bad. These lower ratings can be explained by the fact that few of the residents receive access benefits because of the highway. In the special situation represented by the Puyallup study the beneficial aspects of the highway do not on average outweigh the adverse effects as far as Puyallup residents are concerned. The residents' opinions of the effect of the highway on property values agree with their overall rating. A majority felt that there had been no effect, but 13.8 percent felt they had decreased compared with only 4.6 percent that thought they had increased.

A comparison of the interviews with the earlier hedonic results shows a basic agreement in the conclusions reached. Both show the accessibility benefits to be limited. The interviews may show the highway effects to be slightly more negative than they actually were, which would agree with the Kingsgate results. The hedonic study was unable to measure the noise damages due to the small number of observations, but the results from the other studies generally coincide with the interview statements.

BELLEVUE AREA

In connection with the Bellevue commercial-industrial study, two types of interviews were conducted: interviews with the managers of established firms in the area to learn their impressions of the effects of I-405 on their businesses and interviews with the owners of vacant land in the area to learn their impressions of the effects of the highway on property values. The former type took the form of personal interviews, while the latter were done by mail because the owners were widely dispersed. As expected, the response rate with mail interviews was considerably less than with the other interviews done for this study. Sample interview forms are included in the appendix.

Interviews were done with the managers of 29 firms. Twelve of these were retail establishments emphasizing in-store sales, while seven were retail but with on-site installation of the products. Seven firms were in wholesaling and manufacturing, but these included the largest organizations in the area and a large percentage of the dollar volume of sales. Three firms were specifically travel oriented. With the exception of three sole proprietorships, all the firms were corporations. Approximately half of the sales of these establishments were on-site and half consisted of delivered goods and services.

When asked the reasons that the firm chose to locate in the area, 37.9 percent indicated that transportation availability was an important factor with 31.0 percent indicating that highway transportation was a factor and 13.8 percent saying rail transportation was important. Another 41.4 percent of the managers indicated that customer accessibility was an important factor in the location decision which is another highway-related reason. Other motivations were given which were not transportation-related.

Providing accessibility was the main role that I-405 played in the businesses with 72.4 percent mentioning customer accessibility, 6.9 percent mentioning employee accessibility, and 44.8 percent mentioning goods accessibility. Time-savings were also mentioned but less frequently with 17.2 percent mentioning time-savings in shipping, 6.9 percent mentioning time-savings for customers, and 3.4 percent mentioning time-savings for employees. When asked what was the most important factor in the decision to locate in the study area, a surprising 62.1 percent named accessibility.

Almost two thirds of the managers felt that the highway had increased sales, although there was uncertainty as to how much. Over half felt the highway had also decreased operating costs. The overall rating of the highway averaged between 'good' and 'very good' with 45 percent indicating 'very good'. The magnitude of this effect was considered 'major' by 65.5 percent of those interviewed.

To ascertain the effect, if any, of the highway on property values, interview forms were also sent to the owners of vacant land in the area. The response rate was low with these mailed forms, and only eight valid interviews were returned. Half of these felt that I-405 had influenced the value of the property, along with several other factors. Five felt that the existence of I-405 had influenced their plans to purchase or hold the parcel and that the highway made the land more marketable. Accessibility was the primary benefit, although half also mentioned time-savings. On average, it was felt that the highway had increased property values by 7.5 percent.

Chapter Eleven

Summary and Conclusions

The results reported in the earlier chapters can be combined to provide a fairly complete picture of the effects of highways on property values. There are beneficial effects due to the improvement in accessibility that a highway usually provides for the residents. Unfortunately, for those houses closest to the highway this may be partially offset by the depreciation in property values caused by highway noise. However, the study of the average length of time that is required to sell houses next to the highway and houses further removed indicates that there is no difference other than the price effects. Finally, the interviews revealed that people are fairly well aware of the various effects of highways, but that they may overestimate property value damages due to noise.

Considering first the access benefits, the real estate price indexes in the Kingsgate area indicate an appreciation due to the highway averaging 12 percent. I-405 provided a substantial increase in accessibility to points north and south as well as to Seattle by way of the Lake Washington bridges. In the north King County study area similar time-savings resulted in comparable appreciation of property values of 15 percent. In both these areas the appreciation was best expressed as a percentage of the value of the house rather than as a fixed, absolute amount. This would be expected since the value that a person places on his or her time is related to income, and the more expensive houses are generally occupied by higher income individuals. Thus, the absolute appreciation due to time-savings would be greater for more expensive houses. These studies also indicate that the appreciation does not take place upon the announcement of the highway, but rather after the opening of the highway. On the other hand, in Puyallup few of the residents use SR 512 for commuting. The two methods that were used to test for appreciation indicate that there has been little or no appreciation due to the highway. This was expected since there was little time-saving for residents.

The results from these study areas seem to indicate that improvements in accessibility and time-savings can be reflected in residential property values. However, the magnitude of this effect depends very much on the magnitude of the improvement in accessibility, especially with respect to work trips. Where the improvement was substantial, such as when I-405 or I-5 were opened, property values increased by 12 percent or more. But when few of the residents saved time in their commuting trips, as with SR 512, property values appreciated little if at all because of the highway. In making forecasts of the effect of a change in the highway system, the accessibility improvement must be estimated. The forecast could then be estimated as equal to that in a comparable study area with a comparable improvement. If, however, the area being considered and the access improvement were not quite similar to the relevant study area, then the results of this study should only be used qualitatively in forecasting the direction of effects.

In addition to the access benefits described above, the residential studies also allowed estimation of any negative proximity effects. The measured noise levels were used to assign a noise reading to each house as described above. The effects of this noise on property values was then isolated from the effects of other differences in properties. There was sufficient noise data to obtain this estimate for Kingsgate, north King County, and Spokane. The results are summarized in Table 11-1.

Tests indicated that in each of the study areas the effect of noise was best expressed as a percentage of the value of the home rather than a fixed, absolute amount. In addition tests were performed to examine whether or not noise affects housing prices linearly. The A-weighted decibel scale was designed to approximate human perception of noise, but it is possible that it might not approximate the level of annoyance caused by that noise. Alternative forms for the noise variable were tried, but the linear form proved superior in all three study areas. Ambient noise levels in all three areas were quite comparable, so it was impossible to compare the property value effects of noise in significantly different ambient situations.

The percentage reduction differs in each of the areas, but this is an expected outcome rather than a weakness in the study. Because the housing was already in existence when the highway was constructed in each of the areas, the class of housing differs between areas. As a result, the incomes of the residents also differ. It might well be expected that wealthier individuals would be willing to pay more for quiet in their residences. The studies confirm this since not only are the damages a percentage of the value of the house, but also the magnitudes of the percentages increase with increasing income. The results of this study could be used to forecast the effect in an area where a new highway was proposed. One would determine the income in this new area in 1970 dollars and find the relation to the incomes in the study areas. One could then interpolate between the relevant estimates to determine the anticipated percentage reduction in property values due to the new highway.

Table 11-1

Property Value Depreciation Due to Highway Noise

for Different Areas

Area	Average House Price (1976 Dollars)	Average Income (1970 Census of Population)	Percent Reduction for 2½ dBA Increase in Noise Level above Ambient	Dollar Reduction for Average House for 2½ dBA Increase in Noise Level above Ambient (1976 Dollars)
Kingsgate	$39,244	$14,076	1.20%	$470.82
North King County	$29,834	$12,890	.75%	$223.70
Spokane	$14,617	$ 8,943	.20%	$ 29.23

To estimate the overall effect of a highway on property values, one must consider both the access benefits and adverse noise effects. Table 11-2 summarizes the maximum noise damages for each of the areas. In Kingsgate the 12 percent appreciation due to accessibility improvement more than offsets the 7.2 percent reduction due to noise at the noisiest houses. For the average house in 1976 dollars these figures are $4,709.28 appreciation and $2,824.95 noise damages for a net effect of $1,884.33. In the north King County study area the two percentages are 15 percent appreciation and 6 percent noise damages. The average value house would experience $4,475.10 appreciation and $1,789.64 noise damages for a net appreciation of $2,685.46. These figures only apply to the noisiest houses, and those experiencing less or no noise would receive larger net benefits. One area where this trend may not hold is Puyallup. Because the access benefits are quite small it is possible that the few houses experiencing substantial noise would experience a negative net effect on their property values. This does not suggest that the overall project did not have positive net benefits, but a few households may have been hurt. Judging by the highways studied, this situation is the exception. Generally, even those properties experiencing significant noise tend to appreciate if there is an improvement in accessibility, although by significantly less than similar properties not experiencing the noise but enjoying the accessibility improvement.

In the Bellevue commercial-industrial study after controlling for parcel size, zoning, railroad and street access, and the year of sale,

TABLE 11-2

Maximum Property Value Depreciation at Highest Observed Noise Levels

for Different Areas

Area	Highest Noise Reading	Percent Reduction from Ambient	Dollar Reduction from Ambient for Average House
Kingsgate	70 dBA	7.2%	$2824.95
North King County	75 dBA	6.0%	$1789.64
Spokane	80 dBA	2.0%	$ 292.27

the properties in the study area were shown to have appreciated significantly more than those in the control after the highway was opened. In fact, the differential was 16.7 percent. The improved access for incoming goods and customers for the commercial establishments and incoming and outgoing goods for manufacturers and warehousing provides the motivation for the firms location here. This results in the appreciation of property values. Noise did not appear to have any adverse effects on these properties. As before, in using these results for forecasting the effects of a new highway on property values, one must consider the degree of accessibility improvement that is anticipated.

Many people suggested that the effects of highway noise were not exclusively price effects, but also effects on the length of time required to market houses next to the highway. A publication of a multiple listing real estate organization was used to determine the number of days that houses were on the market both close to I-405 and more removed in the Kingsgate area. There was no statistical difference in the number of days on the market or in the proportion of houses which did not sell within the listing period. Thus the price effects appear to exhaust the influences of highway noise on the marketing of adjacent properties.

The interviews with residents of study areas revealed that individuals have an understanding of both the adverse and beneficial effects of the highway. However, those closest to the highway are less aware of the benefits that the highway contributes, since they tend to concentrate on the adverse effects. The residents in the impact zone also significantly over-estimate the property value damages due to the highway noise by a factor of more than two to one. In the commercial-industrial interviews the managers and land owner seemed well aware of the effects of the highway. They did however underestimate the beneficial effects of the highway on property values. The results in both types of interviews indicated that it might be useful to make sure the public is aware of the conclusions of this study.

The possible applications of these results are many. The most important use is in connection with impact statements and public involvement programs. This application provided the original motivation for the study. The results of this study have quantified the property value effects of a limited-access highway. This information can be utilized for generally assessing property value effects in similar locations when a highway is constructed. Property value effects are a great source of public concern. This evidence will provide facts for detailed discussions on this topic. However, since there can be significant differences between housing markets, it is important that experts familiar with the specific markets be consulted. If the area differs significantly from those studied here, the results can only be applied qualitatively.

There has been substantial interest in partially financing highway construction by capturing part of the accessibility benefits through property taxes. The property value effects are caused by the user benefits from the highway, and do not represent an additional benefit. If existing taxes on highway users are efficient, then there is no need for an additional tax on property from an efficiency standpoint. If additional taxes are indicated, they could take either form with similar long-run effects. A choice between the two must be based on short-run distributional effects. A related point is that care must be used in applying the results of the benefit side of this study to benefit-cost analyses. Double-counting would result if user benefits were fully evaluated and property value effects were added.

These same considerations do not apply to the adverse property value effects of noise. Noise represents an externality which must be considered in benefit-cost analysis in order to make efficient decisions. The distributional effects of these externalities might also be important in evaluating a proposed highway.

Finally, this study might prove useful in making decisions between various transportation modes. Such a choice between modes must be based on all of the effects of the construction of each mode.

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APPENDIX
A

RESULTS OF INTERVIEWS BY STUDY AREA
AND
INTERVIEW FORMS

Kingsgate Area (240 Interviews)

CARD 1 1

QUESTIONNAIRE FOR PROPERTY VALUE STUDY

Residential Area
(Percentages in parenthesis)

Plat 77 2-3 Block 34 4 Lot 25 104 5-7 (1) 8

Location: (32.1%) (1) Abutting highway, (14.2%) (2) Less than one block, (10.4%) (3) One to two blocks, (43.3%) (4) More than two blocks. 9

Name ______ Address ______

1. Adults in household:

A. Age

	20-35 (1)	35-60 (2)	60+ (3)	
Husband	113(47.1%)	117(48.7%)		10
Wife	115(47.9%)	118(49.2%)		11
Single Male	15(6.3%)	5(2.1%)	3(1.2%)	12
Single Female	12(5%)	3(1.2%)	3(1.2%)	13

B. Occupations of adults in household:

78 (32.5%) (1) 14 Professional and Technical (doctors, teachers, engineers, lawyers, etc.)

81 (33.7%) (1) 15 Managerial and Administrative (owners and managers of businesses, governmental administrators, etc.)

57 (23.7%) (1) 16 Clerical (office workers, secretaries, bookkeepers, etc.)

26 (10.8%) (1) 17 Craftsman (carpenters, mechanics, upholsterers, machinists, etc.)

13 (5.4%) (1) 18 Equipment Operators (truck drivers, sewing machine operators, etc.)

12 (5%) (1) 19 Laborers (window washers, hod carriers, track laborers, etc.)

46 (19.2%) (1) 20 Sales Workers (salesman, checkers, clerks, etc.)

21 (8.7%) (1) 21 Service Workers (firemen, policemen, beauticians, practical nurse, etc.)

92 (38.3%) (1) 22 Homemaker

13 (5.4%) (1) 23 Student

3 (1.2%) (1) 24 Retired

16 (6.7%) (1) 25 Other

(Fill in only if not employed in another category greater than 50% of the time)

2. Type of dwelling unit:

Single family dwelling 240 (100%) (1) Duplex ____ (2) Apartment ____ (3) Condominium ____ (4) Other ____ (5) 26

3. Do you own or rent your dwelling? Own 226 (94.2%) (1) Rent 14 (5.8%) (2) 27

4. How long have you lived in your present home? ______ Years 28-29

1	64	(26.7)	5	14	(5.8)	9	15	(6.3)
2	27	(11.2)	6	11	(4.6)	10	7	(2.9)
3	24	(10)	7	17	(7.1)	11	6	(2.5)
4	38	(15.8)	8	14	(5.8)	14	3	(1.2)

5. If you moved into your dwelling unit before the opening of I – 405, did you know that the highway would be built in its present location?

Knew ____ (1) Did not know 24 (10%) (2) 30

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6. Why did you choose to locate in this area?

42 (17.5) (1) 31 Close to work

28 (11.7) (1) 32 Highway accessibility

15 (6.3) (1) 33 Public facilities

70 (29.2) (1) 34 Characteristics of neighborhood

30 (12.5) (1) 35 Nearness of rural areas

13 (5.4) (1) 36 Relatives or close friends

22 (9.2) (1) 37 Age and style of homes

31 (12.9) (1) 38 Price of housing

19 (7.9) (1) 39 Availibility of housing in area

13 (5.4) (1) 40 Amenity such as view or waterfront

33 (13.7) (1) 41 Other, specify ____________________

7. Were there specific reasons you chose this particular dwelling?

82 (34.2) (1) 42 Low price

2 (.8) (1) 43 Relatives or close friends near

56 (23.3) (1) 44 Size of house

80 (33.3) (1) 45 Floor plan

4 (1.7) (1) 46 Surrounding structures

18 (7.5) (1) 47 Amenity such as view or waterfront

43 (17.9) (1) 48 Other, specify ____________________

8. Do you plan to move within the next year? 39 (16.2) (1) Yes 188 (78.3) (2) No 13 (5.4) (3) Uncertain 49

If yes, why?

7 (2.9) (1) 50 Work transfer

11 (4.6) (1) 51 Upgrading dwelling

5 (2.1) (1) 52 Alteration in family needs

4 (1.7) (1) 53 Adverse highway effects

2 (.8) (1) 54 Need less expensive or smaller dwelling

9) 3.7) (1) 55 Prefer different area

Having a major highway near your home may have both good and bad effects. The purpose of this study is to determine the magnitude of these effects and the public's reaction to them. We would like your opinions.

9. Are there benefits to you from having a highway nearby? 219 (91.3) (1) Yes   20 (8.3) (2) No   1 (.4) (3) Uncertain   56

10. What are these?

154 (64.2) (1) 57   Reduced travel time

198 (82.5) (1) 58   Easier accessibility to and from the area

12 (5) (1) 59   Other (specify)

11. If you save time going to work, shopping, recreation, etc., approximately how much time per week do you estimate saving compared with the situation if I-405 had not been built?   60-61   88 (36.7) Don't know

20 (8.3) (1)	0 minutes	30 (12.5) (6)	3-4 hours
6 (2.5) (2)	1-30 minutes	28 (11.7) (7)	4-5 hours
9 (3.7) (3)	31-60 minutes	5 (2.1) (8)	5-7 hours
26 (10.8) (4)	1-2 hours	1 (.4) (9)	7-10 hours
27 (11.2) (5)	2-3 hours	____ (10)	More (specify) ____

There may also be adverse effects caused by the highway.

12. What adverse effects do you notice in the order of their importance?

1 117 (48.7) 2 1 (.4) 62	Noise	1 3 (1.2) 2 1 (.4) 3 1 (.4) (1) 65	Vibration
1 5 (2.1) 2 8 (3.3) 63	Air pollutions	1 4 (1.7) (1) 66	Visual effects 2 1 (.4) 4 1 (.4)
____ 64	Lights	1 28 (11.7) (1) 67	Other (specify) 2 3 (1.2) 3 1 (.4) 5 1 (.4)

13. How would you describe the overall effect of these highway disturbances?

A. Inside your home:

	OBJECTIONABLE (4)	ANNOYING (3)	NOTICEABLE BUT NOT ANNOYING (2)	NOT NOTICEABLE (1)	
Noise	4 (1.7)	20 (8.3)	72 (30)	144 (60)	68
Air Pollution	3 (1.2)	5 (2.1)	8 (3.3)	244 (93.3)	69
Lights			4 (1.7)	236 (98.3)	70
Vibration	2 (.8)	4 (1.7)	4 (1.7)	230 (95.8)	71
Visual Effects	2 (.8)	4 (1.7)	5 (2.1)	229 (95.4)	72

B. Outside your home:

	OBJECTIONABLE (4)	ANNOYING (3)	NOTICEABLE BUT NOT ANNOYING (2)	NOT NOTICEABLE (1)	
Noise	26 (10.8)	21 (8.7)	80 (33.3)	113 (47.1)	73
Air Pollution	5 (2.1)	4 (1.7)	11 (4.6)	220 (91.6)	74
Lights			5 (2.1)	235 (97.9)	75
Vibration	2 (.8)	4 (1.7)	5 (2.1)	229 (95.4)	76
Visual Effects	2 (.8)	4 (1.7)	5 (2.1)	229 (95.4)	77

14. At what time of day do you find the highway effects most annoying? 78

11(4.6) (1)	Midnight to 6 a.m.	30(12.5) (5)	4 p.m. – 6 p.m.
26(10.8) (2)	6 a.m. – 8 a.m.	7(2.9) (6)	6 p.m. – 8 p.m.
____ (3)	8 a.m. to noon	17(7.1) (7)	8 p.m. to midnight
1(.4) (4)	Noon to 4 p.m.		

0	133(55.9)	7	1(.4)
1	99(41.2)		
2	5(2.1)		
3	2(.8)		

15. How many persons occupy the dwelling during a weekday between 8 a.m. and 5 p.m.? 3 2(.8) 79

16. When comparing all of the good and bad effects of the highway upon your living conditions, how would you evaluate the overall effect of the freeway? 80

73(30.4) (1)	Very good	22(9.2) (4)	Bad
98(40.8) (2)*	Good	2 (.8) (5)	Very bad
44(18.3) (3)	Neutral		

CARD 2 (1)

Plat ____________ 2-3 Block ____________ 4 Lot ____________ 5-7

17. Do you feel that the value of your property has increased or decreased as a result of the highway?

74 (30.8) (1) Increased 43 (17.9) (2) Decreased 83 (34.6) (3) No Effect 40 (16.7) (4) Uncertain

If you believe property value has increased or decreased as a result of the highway, can you estimate the approximate amount: 9-10

3 (1.2) (1)	Down between 5 and 10 thousand dollars	5(2.1) (8)	Up between 0 and 1 thousand dollars
7 (2.9) (2)	Down between 4 and 5 thousand dollars	9 (3.7) (9)	Up between 1 and 2 thousand dollars
5 (2.1) (3)	Down between 3 and 4 thousand dollars	6 (2.5) (10)	Up between 2 and 3 thousand dollars
7 (2.9) (4)	Down between 2 and 3 thousand dollars	1 (.4) (11)	Up between 3 and 4 thousand dollars
6 (2.5) (5)	Down between 1 and 2 thousand dollars	6 (2.5) (12)	Up between 4 and 5 thousand dollars
2 (.8) (6)	Down between 0 and 1 thousand dollars	3 (1.2) (13)	Up between 5 and 10 thousand dollars
83 (34.6) (7)	No effect	4 (1.7) (14)	Up more than 10 thousand dollars

18. Would you ever again buy or rent or build a home this close to a major highway? 11

165(68.8) (1) Yes 51(21.2) (2) No 23(9.6) (3) Maybe

19. Have there been any important changes in the neighborhood other than the highway that you feel have affected the value of your home? 12

____ (1) Yes ____ (2) No ____ (3) Uncertain

Specify: ____

____

20. When you purchased this dwelling was any personal property included in the sales price?

- 2(.8) (1) 13 Completely furnished
- ______ (1) 14 Partially furnished
- ______ (1) 15 1 - 3 pieces of furniture
- 51(21.2) (1) 16 Drapes
- 20 (8.3) (1) 17 Appliances
- ______ (1) 18 Carpets - not attached
- 17(7.1) (1) 19 Other (specify) ______

21. In what general areas do people living in your household work?

- 93(38.7) 20 Downtown Seattle
- 3(1.2) 21 Duwamish Industrial Area
- 16(6.7) 22 University District
- 20(8.3) 23 Renton
- 49(20.4) 24 Bellevue
- 30(12.5) 25 Kirkland
- 16(6.7) 26 Redmond
- 21(8.7) 27 Bothell
- 22(9.2) 28 North Seattle
- 21(8.7) 29 South Seattle
- 16(6.7) 30 Snohomish County
- 7(2.9) 31 Eastern King County
- 26(10.8) 32 Other, specify ______

Who was interviewed?

Male	125 (52.1)
Female	142 (59.2)

Noise Contour Level

0	146	(60.8)
1	11	(4.6)
2	14	(5.8)
3	18	(7.5)
4	41	(17.1)
5	8	(3.3)
6	1	(.4)
7	1	(.4)

Kingsgate Area within 600' (114 Interviews)

CARD 1 (1)

QUESTIONNAIRE FOR PROPERTY VALUE STUDY

Residential Area

(Percentages in parentheses)

Plat 76 (2-3) Block 26 (4) Lot 11 (5-7) (1) 1 (8)

Location: (66.7) (1) Abutting highway, (22.8) (2) Less than one block, (9.6) (3) One to two blocks, (.9) (4) More than two blocks. 9

Name ______ Address ______

1. Adults in household:

A. Age

	20-35 (1)	35-60 (2)	60+ (3)	
Husband	48(42.1)	63(55.3)		10
Wife	48(42.1)	64(56.1)		11
Single Male	9(7.9)	4(3.5)	1(.9)	12
Single Female	6(5.3)	2(1.8)	3(2.6)	13

B. Occupations of adults in household:

42(36.9) (1)	14	Professional and Technical (doctors, teachers, engineers, lawyers, etc.)
33(28.9) (1)	15	Managerial and Administrative (owners and managers of businesses, governmental administrators, etc.)
35(30.7) (1)	16	Clerical (office workers, secretaries, bookkeepers, etc.)
14(12.3) (1)	17	Craftsman (carpenters, mechanics, upholsterers, machinists, etc.)
8(7) (1)	18	Equipment Operators (truck drivers, sewing machine operators, etc.)
6(5.3) (1)	19	Laborers (window washers, hod carriers, track laborers, etc.)
24(21.1) (1)	20	Sales Workers (salesman, checkers, clerks, etc.)
8(7) (1)	21	Service Workers (firemen, policemen, beauticians, practical nurse, etc.)
45(39.5) (1)	22	Homemaker
8(7) (1)	23	Student
1(.9) (1)	24	Retired
3(2.6) (1)	25	Other

(Homemaker, Student, Retired, Other: Fill in only if not employed in another category greater than 50% of the time)

2. Type of dwelling unit:

Single family dwelling 114 (1) Duplex ___ (2) Apartment ___ (3) Condominium ___ (4) Other ___ (5) 26

109 5

3. Do you own or rent your dwelling? Own (95.6) (1) Rent (4.4) (2) 27

4. How long have you lived in your present home? ___ Years 28-29

1	22	(19.3)	5	7	(6.1)	9	11	(9.6)
2	15	(13.2)	6	5	(4.4)	10	6	(5.)
3	8	(7)	7	11	(9.6)	11	5	(4.4)
4	15	(13.2)	8	9	(7.9)			

5. If you moved into your dwelling unit before the opening of I – 405, did you know that the highway would be built in its present location?

Knew ___ (1) Did not know 19(16.7) (2) 30

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6. Why did you choose to locate in this area?

18(15.8) (1) 31 Close to work

12(10.5) (1) 32 Highway accessibility

8(7.0) (1) 33 Public facilities

37(32.5) (1) 34 Characteristics of neighborhood

10(8.8) (1) 35 Nearness of rural areas

8(7) (1) 36 Relatives or close friends

13(11.4) (1) 37 Age and style of homes

14(12.3) (1) 38 Price of housing

13(11.4) (1) 39 Availibility of housing in area

6(5.3) (1) 40 Amenity such as view or waterfront

8(7) (1) 41 Other, specify ______________________

7. Were there specific reasons you chose this particular dwelling?

36(31.6) (1) 42 Low price

1(.9) (1) 43 Relatives or close friends near

29(25.4) (1) 44 Size of house

41(36) (1) 45 Floor plan

4(3.5) (1) 46 Surrounding structures

11(9.6) (1) 47 Amenity such as view or waterfront

19(16.7) (1) 48 Other, specify ______________________

8. Do you plan to move within the next year? 18 (15.8) (1) Yes 92 (80.7) (2) No 4 (3.6) (3) Uncertain 49

If yes, why?

2(1.8) (1) 50 Work transfer

3(2.6) (1) 51 Upgrading dwelling

2(1.8) (1) 52 Alteration in family needs

4(3.5) (1) 53 Adverse highway effects

---- (1) 54 Need less expensive or smaller dwelling

5 (4.4) (1) 55 Prefer different area

Having a major highway near your home may have both good and bad effects. The purpose of this study is to determine the magnitude of these effects and the public's reaction to them. We would like your opinions.

9. Are there benefits to you from having a highway nearby? 94(82.5) Yes (1) 19(16.7) No (2) 1(.9) Uncertain (3) 56

10. What are these?

47(41.2) (1)	57	Reduced travel time
83(72.8) (1)	58	Easier accessibility to and from the area
8(7) (1)	59	Other (specify)

11. If you save time going to work, shopping, recreation, etc., approximately how much time per week do you estimate saving compared with the situation if I-405 had not been built? 75-76

16(14) (1)	0 minutes	15(13.2) (6)	3-4 hours
3(2.6) (2)	1-30 minutes	11(9.6) (7)	4-5 hours
3(2.6) (3)	31-60 minutes	4(3.5) (8)	5-7 hours
6(5.3) (4)	1-2 hours	____ (9)	7-10 hours
10(8.8) (5)	2-3 hours	____ (10)	More (specify) ____

There may also be adverse effects caused by the highway.

CARD 2 (1)

Code No. ____ 2-4

12. What adverse effects do you notice in the order of their importance?

1 83 (72.8)
2 1 (0.9) 5 Noise
1 3 (2.6)
2 8 (7) 6 Air pollutions
____ 7 Lights

1 3 (2.6)
3 1 (.9) 8 Vibration
1 3(2.6) 4 1 (.9)
2 1(.9) 9 Visual effects
1 12 (10.5)
2 3 (2.6) 10 Other (specify) ____
3 1 (.9)
5 1 (.9)

13. How would you describe the overall effect of these highway disturbances?

A. Inside your home:

	OBJECTIONABLE (4)	ANNOYING (3)	NOTICEABLE BUT NOT ANNOYING (2)	NOT NOTICEABLE (1)	
Noise	4 (3.5)	19(16.7)	52(45.6)	39(34.2)	11
Air Pollution	3 (2.6)	4(3.5)	8(7)	99(86.9)	12
Lights			3(2.6)	111(97.3)	13
Vibration	2 (1.8)	3(2.6)	4(3.5)	105(92.1)	14
Visual Effects	2 (1.8)	3(2.6)	5(4.4)	104(91.2)	15

B. Outside your home:

	OBJECTIONABLE (4)	ANNOYING (3)	NOTICEABLE BUT NOT ANNOYING (2)	NOT NOTICEABLE (1)	
Noise	25(21.9)	15(13.2)	47(41.2)	27(23.7)	16
Air Pollution	5(4.4)	3(2.6)	10(8.8)	96(84.2)	17
Lights			4(3.5)	110(96.5)	18
Vibration	2(1.8)	3(2.6)	5(4.4)	104(91.2)	19
Visual Effects	2(1.8)	3(2.6)	5(4.4)	104(91.2)	20

14. At what time of day do you find the highway effects most annoying? 78

6(5.3) (1) Midnight to 6 a.m.
20(17.5) (2) 6 a.m. – 8 a.m.
____ (3) 8 a.m. to noon
1(.9) (4) Noon to 4 p.m.
24(21.1) (5) 4 p.m. – 6 p.m.
3(2.6) (6) 6 p.m. – 8 p.m.
14(12.3) (7) 8 p.m. to midnight

15. How many persons occupy the dwelling during a weekday between 8 a.m. and 5 p.m.? 79

0 52(45.6)
1 56(49.1)
2 4(3.5)
3 2(1.8)

16. When comparing all of the good and bad effects of the highway upon your living conditions, how would you evaluate the overall effect of the freeway? 80

11(9.6) (1) Very good
47(41.2) (2) Good
33(28.9) (3) Neutral
21(18.4) (4) Bad
2(1.8) (5) Very bad

CARD [2] 1

Plat ____________ 2-3 Block ____________ 4 Lot ____________ 5-7

17. Do you feel that the value of your property has increased or decreased as a result of the highway?

15(13.2) (1) Increased 41(36) (2) Decreased 36(31.6) (3) No Effect 22(19.3) (4) Uncertain

If you believe property value has increased or decreased as a result of the highway, can you estimate the approximate amount: 9-10

3(2.6) (1) Down between 5 and 10 thousand dollars
7(6.1) (2) Down between 4 and 5 thousand dollars
5 (4.4) (3) Down between 3 and 4 thousand dollars
7(6.1) (4) Down between 2 and 3 thousand dollars
5(4.4) (5) Down between 1 and 2 thousand dollars
2(1.8) (6) Down between 0 and 1 thousand dollars
26(22.8) (7) No effect
1 (.9) (8) Up between 0 and 1 thousand dollars
2(1.8) (9) Up between 1 and 2 thousand dollars
1 (.9) (10) Up between 2 and 3 thousand dollars
1 (.9) (11) Up between 3 and 4 thousand dollars
2(1.8) (12) Up between 4 and 5 thousand dollars
---- (13) Up between 5 and 10 thousand dollars
1 (.9) (14) Up more than 10 thousand dollars

18. Would you ever again buy or rent or build a home this close to a major highway? 11

63 (55.3) (1) Yes 37 (32.5) (2) No 13 (11.4) (3) Maybe

19. Have there been any important changes in the neighborhood other than the highway that you feel have affected the value of your home? 12

____ (1) Yes ____ (2) No ____ (3) Uncertain

Specify: ____

____

20. When you purchased this dwelling was any personal property included in the sales price?

- ____ (1) 13 Completely furnished
- ____ (1) 14 Partially furnished
- ____ (1) 15 1 - 3 pieces of furniture
- ____ (1) 16 Drapes
- ____ (1) 17 Appliances
- ____ (1) 18 Carpets - not attached
- ____ (1) 19 Other (specify) ____

21. In what general areas do people living in your household work?

- 48 (42.1) 20 Downtown Seattle
- 2 (1.8) 21 Duwamish Industrial Area
- 8 (7) 22 University District
- 10 (8.8) 23 Renton
- 20 (17.6) 24 Bellevue
- 12 (10.5) 25 Kirkland
- 11 (9.6) 26 Redmond
- 9 (7.9) 27 Bothell
- 13 (11.4) 28 North Seattle
- 10 (8.8) 29 South Seattle
- 8 (7) 30 Snohomish County
- 4 (3.5) 31 Eastern King County
- 14 (12.3) 32 Other, specify ____

Who was interviewed?

Male 55 (51.8)
Female 75 (65.8)

Noise Contour Level

0	20	(17.5)
1	11	(9.6)
2	14	(12.3)
3	18	(15.8)
4	41	(36.0)
5	8	(7.0)
6	1	(0.9)
7	1	(0.9)

Puyallup Area (109 Interviews)

CARD 1

QUESTIONNAIRE FOR PROPERTY VALUE STUDY

Residential Area

(Percentages in Parentheses)

Code No. ______ 2-4

Location: 25 (22.9) (1) Abutting highway, 36 (33.0) (2) Less than one block, 9 (8.3) (3) One to two blocks, 39 (35.8) (4) More than two blocks. 5

Name ______ Address ______

1. Adults in household:

A. Age

	20-35 (1)	35-60 (2)	60+ (3)		None	Persons Interviewed		
Husband	38(34.9)	47(43.1)	13(11.9)	6	11(10.1)	Husband	38(34.9) (1)	10
Wife	38(34.9)	47(43.1)	17(15.6)	7	7(6.4)	Wife	48(44.0) (1)	11
Single Male	12(11.0)	4(3.7)	1(0.9)	8	92(84.4)	Single Male	4(3.7) (1)	12
Single Female	10(9.2)		2(1.8)	9	97(89.0)	Single Female	6(5.5) (1)	13

B. Occupations of adults in household:

(1)	(2)		
22 (20.2)	5 (4.6)	14	Professional and Technical (doctors, teachers, engineers, lawyers, etc.)
18 (16.5)	3 (2.8)	15	Managerial and Administrative (owners and managers of businesses, governmental administrators, etc.)
15 (13.8)	3 (2.8)	16	Clerical (office workers, secretaries, bookkeepers, etc.)
17 (15.6)	1 (0.9)	17	Craftsman (carpenters, mechanics, upholsterers, machinists, etc.)
5 (4.6)	1 (0.9)	18	Equipment Operators (truck drivers, sewing machine operators, etc.)
2 (1.8)		19	Laborers (window washers, hod carriers, track laborers, etc.)
2 (1.8)		20	Sales Workers (salesman, checkers, clerks, etc.)
9 (8.3)		21	Service Workers (firemen, policemen, beauticians, practical nurse, etc.)
42 (38.5)		22	Homemaker
5 (4.6)	3 (2.8)	23	Student
13 (11.9)	19 (17.4)	24	Retired
5 (4.6)		25	Other

(Homemaker, Student, Retired, Other: Fill in only if not employed in another category greater than 50% of the time)

C. In what general areas do people living in your household work?

29 (26.6)	8 (7.3)	26	Puyallup	17 (15.6)	1 (0.9)	32	Downtown Tacoma
3 (2.8)		27	Sumner	11 (10.1)		33	Tacoma Port Area
0		28	East of Puyallup	4 (3.7)		34	Nalley Valley - Tacoma Mall
1 (0.9)		29	South of Puyallup	9 (8.3)	1 (0.9)	35	Kent - Auburn
0		30	East of Lake Washington	5 (4.6)	1 (0.9)	36	Military Bases
14 (12.8)	1 (0.9)	31	Seattle Area	2 (1.8)		37	Olympic Peninsula

5(4.6) 38 Other, specify ______

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2. Type of dwelling unit:

Single family dwelling 98 (89.9) (1) Duplex 2 (1.8) (2) Apartment ____ (3) Condominium ____ (4) Other ____ (5) 39

3. Do you own or rent your dwelling? Own 95 (87.2) (1) Rent 14 (12.8) (2) 40

4. How long have you lived in your present home? ____ Years 41-42 Mean 13.1

5. If you moved into your dwelling unit before the opening of SR 512, did you know that the highway would be built in its present location?

Knew 37 (33.9) (1) Did not know 72 (66.1) (2) 43

6. Why did you choose to locate in this area?

- 17 (15.6) (1) 44 Close to work
- 2 (1.8) (1) 45 Highway accessibility
- 8 (7.3) (1) 46 Public facilities
- 23 (21.1) (1) 47 Characteristics of neighborhood
- 20 (18.3) (1) 48 Nearness of rural areas
- 12 (11.0) (1) 49 Relatives or close friends
- 5 (4.6) (1) 50 Age and style of homes
- 5 (4.6) (1) 51 Price of housing
- 20 (18.3) (1) 52 Availability of housing in area
- 6 (5.5) (1) 53 Amenity such as view or waterfront
- 13 (11.9) (1) 54 Other, specify ____

7. Were there specific reasons you chose this particular dwelling?

- 29 (26.6) (1) 55 Low price
- 3 (2.8) (1) 56 Relatives or close friends near
- 15 (13.8) (1) 57 Size of house
- 15 (13.8) (1) 58 Floor plan
- 2 (1.8) (1) 59 Surrounding structures
- 4 (3.7) (1) 60 Amenity such as view or waterfront
- 29 (26.6) (1) 61 Available
- 24 (22.0) (1) 62 Other, specify ____

8. Do you plan to move within the next year? 14 (28.8) (1) Yes 77 (70.6) (2) No 14 (12.8) (3) Uncertain 63

If yes, why?

- 2 (1.8) (1) 64 Work transfer
- 3 (2.8) (1) 65 Upgrading dwelling
- 3 (2.8) (1) 66 Alteration in family needs
- 5 (4.6) (1) 67 Adverse highway effects
- 1 (0.9) (1) 68 Need less expensive or smaller dwelling
- – (1) 69 Prefer different area
- 6 (5.5) (1) 70 Going from rental to purchase

Having a major highway near your home may have both good and bad effects. The purpose of this study is to determine the magnitude of these effects and the public's reaction to them. We would like your opinions.

9. Are there benefits to you from having a highway nearby? 56 (51.4) (1) Yes 51 (46.8) (2) No 2 (1.8) (3) Uncertain 71

10. What are these?

- 27 (24.8) (1) 72 Reduced travel time
- 47 (43.1) (1) 73 Easier accessibility to and from the area
- 1 (0.9) (1) 74 Other (specify) ____

11. If you save time going to work, shopping, recreation, etc., approximately how much time per week do you estimate saving compared with the situation if SR 512 had not been built? 75-76

87 (79.8) (1)	0 minutes	____ (6)	3-4 hours
4 (3.7) (2)	1-30 minutes	____ (7)	4-5 hours
3 (2.8) (3)	31-60 minutes	____ (8)	5-7 hours
13 (11.9) (4)	1-2 hours	____ (9)	7-10 hours
2 (1.8) (5)	2-3 hours	____ (10)	More (specify) ____

There may also be adverse effects caused by the highway.

12. What adverse effects do you notice in the order of their importance?

CARD [2] 1

Code No. ____ 2-4

33 1 (30.3) (0.9) 5	Noise	0 6 (5.5) 8	Vibration
2 3 (1.8) (2.8) 6	Air pollutions	0 1 (0.9) 9	Visual effects
____ 7	Lights	14 3 (12.8) (2.8) 10	Other (specify) ____

13. How would you describe the overall effect of these highway disturbances?

A. Inside your home:

	OBJECTIONABLE (4)	ANNOYING (3)	NOTICEABLE BUT NOT ANNOYING (2)	NOT NOTICEABLE (1)	
Noise	5 (4.6)	4 (3.7)	19 (17.4)	81 (74.3)	11
Air Pollution	1 (0.9)			108 (99.1)	12
Lights				109 (100.0)	13
Vibration	1 (0.9)	1 (0.9)	2 (1.8)	105 (96.4)	14
Visual Effects			1 (0.9)	108 (99.1)	15

B. Outside your home:

	OBJECTIONABLE (4)	ANNOYING (3)	NOTICEABLE BUT NOT ANNOYING (2)	NOT NOTICEABLE (1)	
Noise	11 (10.1)	7 (6.4)	11 (10.1)	80 (73.4)	16
Air Pollution	2 (1.8)			107 (98.2)	17
Lights		1 (0.9)	1 (0.9)	107 (98.2)	18
Vibration	1 (0.9)		1 (0.9)	107 (98.2)	19
Visual Effects	1 (0.9)		1 (0.9)	107 (98.2)	20

14. At what time of day do you find the highway effects most annoying? 21

7 (6.4) (1)	Midnight to 6 a.m.	5 (4.6) (5)	4 p.m. – 6 p.m.
7 (6.4) (2)	6 a.m. – 8 a.m.	____ (6)	6 p.m. – 8 p.m.
____ (3)	8 a.m. to noon	1 (0.9) (7)	8 p.m. to midnight
1 (0.9) (4)	Noon to 4 p.m.		

15. How many persons occupy the dwelling during a weekday between 8 a.m. and 5 p.m.? 22

0	1	2	3
40	50	18	1
(36.7)	(45.9)	(16.5)	(0.9)

16. When comparing all of the good and bad effects of the highway upon your living conditions, how would you evaluate the overall effect of the freeway? 23

14(12.8) (1) Very good
37(33.9) (2) Good
41(37.6) (3) Neutral
11(10.1) (4) Bad
3(2.8) (5) Very bad

17. Do you feel that the value of your property has increased or decreased as a result of the highway? 24

5 (4.6) (1) Increased 15 (13.8) (2) Decreased 58 (53.2) (3) No Effect 25 (22.9) (4) Uncertain

If you believe property value has increased or decreased as a result of the highway, can you estimate the approximate amount 25-26

____ (1) Down between 5 and 10 thousand dollars
1(0.9) (2) Down between 4 and 5 thousand dollars
2(1.8) (3) Down between 3 and 4 thousand dollars
____ (4) Down between 2 and 3 thousand dollars
____ (5) Down between 1 and 2 thousand dollars
____ (6) Down between 0 and 1 thousand dollars
____ (7) No effect
____ (8) Up between 0 and 1 thousand dollars
____ (9) Up between 1 and 2 thousand dollars
1(0.9) (10) Up between 2 and 3 thousand dollars
____ (11) Up between 3 and 4 thousand dollars
____ (12) Up between 4 and 5 thousand dollars
____ (13) Up between 5 and 10 thousand dollars
____ (14) Up more than 10 thousand dollars

18. Would you ever again buy or rent or build a home this close to a major highway? 27

58 (53.2) (1) Yes 39 (35.8) (2) No 10 (9.2) (3) Maybe

19. Have there been any important changes in the neighborhood other than the highway that you feel have affected the value of your home? 28

51 (46.8) (1) Yes 51 (46.8) (2) No 5 (4.6) (3) Uncertain

Specify: ____________________

____

20. When you purchased this dwelling was any personal property included in the sales price?

____ (1) 29 Completely furnished
____ (1) 30 Partially furnished
____ (1) 31 1 - 3 pieces of furniture
11(10.1) (1) 32 Drapes
11(10.1) (1) 33 Appliances
2(1.8) (1) 34 Carpets - not attached
1(0.9) (1) 35 Other (specify) ____________________

1

1

VACANT LAND INTERVIEW FORM

CODE ________ 2-4

Name: ________________________________

Address: ________________________________

SQS ________ 5-7

Property: ________________________________

The Washington State Highway Department is currently carrying out a federally-funded study of the effects of a major highway on nearby property owners. These questions refer to the property you currently own or did own in the vicinity of Interstate - 405 and the Bel-Red Road.

1. How long ago did this property come under your ownership? ______ yrs. 8-9

2. If you have since sold it, how long ago was this done? ______ yrs. 10-11

3. Did you purchase this property from an unrelated individual or obtain it by some other means?(Check one) 12

   ______ (1) arms-length sale

   ______ (2) purchased from relative

   ______ (3) gift

   ______ (4) inheritance

   ______ (5) other, specify: ________________________________

4. What were your goals in purchasing or holding this property? (Check all applicable)

   ______ (1) 13 purchased for third party

   ______ (1) 14 short-term investment (less than 3 yrs.)

   ______ (1) 15 long-term investment (more than 3 yrs.)

   ______ (1) 16 personal residential use

   ______ (1) 17 personal business use

   ______ (1) 18 inertia

   ______ (1) 19 other, specify ________________________________

5. What changes do you feel have influenced the value of this piece of property? (Check all applicable)

   ______ (1) 20 I-405

   ______ (1) 21 commercial growth of area

   ______ (1) 22 industrial growth of area

   ______ (1) 23 eastside population growth

   ______ (1) 24 zoning change

   ______ (1) 25 nothing

   ______ (1) 26 other, specify: ________________________________

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6. Has the zoning of the property changed ? ____ year 27-28 ____ original designation 29-30 ____ new designation 31-32

What percentage change in your property value do you estimate this made? ____________ . 33-35

7. When you obtained this property, was I-405 open? ____ (1) yes ____ (2) no ____ (3) uncertain 36

If not, were you aware of the I-405 plans? ____ (1) knew ____ (2) did not know 37

8. Did the existence of I-405 or its plans influence your decision to purchase or hold this land?

____ (1) yes ____ (2) no ____ (3) uncertain 38

9. How do you believe your property value has changed compared with the situation if I-405 had not been built?

____ (1) up ____ (2) down ____ (3) no effect ____ (4) uncertain 39

How much? ____ % up 40-42 ____ % down 43-45

10. Has the existence of I-405 influenced the marketability of the land? 47

____ (1) less marketable

____ (2) no effect

____ (3) more marketable

11. When you sell or build, what beneficial effects of the highway do you anticipate?

____ (1) 48 accessibility for customers

____ (1) 49 accessibility for employees

____ (1) 50 accessibility for goods

____ (1) 51 time-savings for customers

____ (1) 52 time-savings for employees

____ (1) 53 time-savings for goods

____ (1) 54 visibility to passersby

____ (1) 55 increased traffic

____ (1) 56 other, specify ____________________

12. What adverse highway effects do you anticipate?

____ (1) 57 noise

____ (1) 58 air pollution

____ (1) 59 vibration

____ (1) 60 visual effects

____ (1) 61 increased traffic

____ (1) 62 other, specify ____________________

13. Overall, how would you rate the effect of I-405 on your land?

____ (1) very good   ____ (2) good   ____ (3) neutral   ____ (4) bad   ____ (5) very bad 63

14. If you have sold the property, what was the reason? 64

____ (1) received as good an offer as could anticipate.

____ (2) wanted to invest the money elsewhere for better return.

____ (3) other, specify: ____

15. If you still hold the property, what actions do you intend?

	65		66-67		68-69	
hold indefinitely	____ (1)					
already leased	____ (2)	leased	____	yrs. ago for	____	yrs.
			70-71		72	
lease	____ (3)	in	____	yrs.	____	ASAP*
			73-74		75	
sell	____ (4)	in	____	yrs.	____	ASAP*

*(As soon as possible)

2 (1)   CODE ________ 2-4

16. What use do you anticipate will be made of the land?

____ (1) 5 retail

____ (1) 6 wholesale

____ (1) 7 warehousing

____ (1) 8 industrial

____ (1) 9 service

____ (1) 10 professional

____ (1) 11 residential

____ (1) 12 none

17. What is your occupation in general terms? 13-14

____ (1) real estate

____ (2) development

____ (3) professional and technical (doctors, teachers, engineers, lawyers, etc.)

____ (4) managerial and administrative (owners and managers of businesses, governmental administrators, etc.)

____ (5) clerical (office workers, secretaries, bookkeepers, etc.)

____ (6) craftsman (carpenters, mechanics, upholsterers, machinists, etc.)

____ (7) equipment operators (truck drivers, sewing machine operators, etc.)

____ (8) laborers (window washers, hod carriers, track laborers, etc.)

___ (9) sales workers (salesmen, checkers, clerks, etc.)

___ (10) service workers (firemen, policemen, beauticians, practical nurse, etc.)

___ (11) Homemaker

___ (12) Student

___ (13) Retired

___ (14) Other

} Fill in only if not employed in another category greater than 50% of the time.

Person interviewed:

A. Sex ___ (1) M ___ (2) F. 15

B. Age ___ (1) 20-35 ___ (2) 35-60 ___ (3) 60 plus. 16

IMPROVED PROPERTY INTERVIEW FORM

CODE ________ 2-4

Person Interviewed ________________________________

Position ________________ Length of time held ________ years 5-6

Firm ________________ Type of Business ________ Code ____ 7-8

Property ________________________________ SQS ____ 9-11

The Washington State Highway Department is currently carrying out a federally-funded study of the effects of a major highway on nearby property owners. These questions refer to the effects of Interstate 405 on your firm's business.

1. This business is a: 12

   ____ Sole Proprietorship (1)

   ____ Partnership (2)

   ____ Private Corporation (3)

   ____ Non-Profit Corporation (4)

   ____ Other (specify): ________________ (5)

2. What percent of the firm's gross sales is in each of the following categories?

   a. Retail
      Sale of Products ______ % 13-15

      Sale of Services ______ % 16-18

      Wholesale ______ % 19-21

      Manufacturing ______ % 22-24

      Other (specify) ______ % 25-27 ________________

   b. ______ % on-site sales. 28-30

      ______ % delivered goods or services sales. 31-33

3. Does the firm own or lease this property?

   Own (1) ____ 34
   How long has your business been located here? ______ years 36-37

   Lease (1) ____ 35
   How many years ago did the current lease begin? ______ years 38-39

   How long is the lease? ______ years 40-41

   Did you have other leases on this property before the current one? ____ yes (1) ____ no (2) 42

How long has your business been located here? __________ years 43-44

Who is the current owner of the property? Name: ____________________

Address: ______________________________ Phone: __________

Is the lease based on a flat rate ____ (1) ; % gross sales ____ (2) ; other __________ (3) , 45

specify: ______________________________

How often can the rate or % be adjusted? Every ____ years. 46-47

Do you feel the opening of I-405 resulted in changes in the rate or percentage? ____ (1) yes, ____ (2) no, ____ (3) maybe 48

What is the current rent? flat ______ / month (49-53) ______ / year. (54-58)

percentage ______ % 59-60 both ______ (1) 61

What was the rate before I-405? flat ______ / month (62-66) ______ / year. (67-71)

percentage ______ % 72-73 both ______ (1) 74

4. Does your firm have any definite plans to move within the next three years? ____ (1) yes ____ (2) no ____ (3) maybe 75

What are the reasons?

____ (1) 76 changing highway needs. (Specify) ______________________________

____

____

____ (1) 77 changing area character

____ (1) 78 expansion

____ (1) 79 more customer access in a new location

____ (1) 80 other, specify: ______________________________

2 (1) CODE __________ 2-4

5. What are the reasons your firm chose to locate here initially?

____ (1) 5 transportation availability: highway ____ (1) 6 rail ____ (1) 7

____ (1) 8 customer accessibility

____ (1) 9 visibility

____ (1) 10 tax structure

____ (1) 11 untapped market

____ (1) 12 other, specify: ______________________________

6. What role does I-405 play in your business?

- ______ (1) 13 customer accessibility
- ______ (1) 14 employee accessibility
- ______ (1) 15 goods accessibility
- ______ (1) 16 generating traffic
- ______ (1) 17 time savings in shipping
- ______ (1) 18 time savings for customers
- ______ (1) 19 time savings for employees
- ______ (1) 20 other, specify: ______

	Bellevue	E. of Lake Washington (not in Bellevue)	W. of Lake Washington	More Distant Locations	TOTAL	
7. Please estimate what percent of your retail customers live in each of the following areas.	21-23	24-26	27-29	30-32		100% or 0%
8. Please estimate what percent of your wholesale, drop-in customers are located in each of the following areas.	33-35	36-38	39-41	42-44		100% or 0%
9. Please estimate what percent of your goods are shipped to each of the following areas.	45-47	48-50	51-53	54-56		100% or 0%
10. Approximately what percent of goods and material used or sold by your firm are purchased from businesses located in each of the following areas.	57-59	60-62	63-65	66-68		100%
11. Please estimate what percent of your employees live in each of the following areas.	69-71	72-74	75-77	78-80		100%

3 1 CODE ______ 2-4

12. There are many factors that interact to affect the operation of a business. Location is one of these factors. What do you consider to be the most desirable and the most undesirable aspect of your present location?

Most desirable: ______ 5-6

______

Most undesirable: ______ 7-8

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13. I-405 has had what effect on the gross sales of your business?

Increase ___ (1) Decrease ___ (2) No Change ___ (3) 9 ___ % 10-12

14. In what way do you feel I-405 has affected the firm's total operating costs?

Increase ___ (1) Decrease ___ (2) No change ___ (3) 13 ___ % 14-16

15. In what way do you feel I-405 has affected the transportation portion of the firm's operating costs?

Increase ___ (1) Decrease ___ (2) No change ___ (3) 17 ___ % 18-20

16. In 1973 approximately what proportion of your cost of doing business was for Transportation Expenses? ___ % 21-23

17. Would you have located here if I-405 had not been in existence? ___ (1) yes ___ (2) no ___ (3) uncertain 24

18. Do you find Highway 520 has an effect on your business? 25

___ (1) yes, more than 405

___ (2) yes, as much as 405

___ (3) yes, but less than 405

___ (4) no

___ (5) uncertain

19. Are there any adverse effects on your business from 405?

___ (1) 26 noise

___ (1) 27 air pollution

___ (1) 28 vibration

___ (1) 29 visual effects

___ (1) 30 increased traffic

___ (1) 31 other, specify: ___

20. Overall, how would you rate the effect of I-405 on your firm's business?

a. very good ___ (1) good ___ (2) neutral ___ (3) bad ___ (4) very bad ___ (5) 32

b. major ___ (1) minor ___ (2) none ___ (3) 33

APPENDIX

B

SUMMARY OF REPORT

For Use in Implementation

SUMMARY REPORT

Transportation improvements of all kinds are being evaluated more carefully than ever during the planning stages. This attention to detail is well justified because the implications of such projects transcend the engineering disciplines and have environmental, social, and economic effects of major importance. In the economic area one of the impacts that is of great concern to the public is the effect of a highway on property values. The purpose of this study is to measure the beneficial and adverse effects of limited-access highways on property values. A need exists in the State of Washington to have current data and analyses concerning this subject that apply specifically to this state. In addition there have been several theoretical developments that allow refinement of previous studies and validation of their results.

Overview

This study analyzed the beneficial effects of a highway on the values of surrounding properties by determining the real estate price trends in areas where a highway was constructed and comparing these trends with those in comparable areas which did not experience such changes. There were four residential areas utilized for parts of this study: Kingsgate east of Lake Washington on I-405, north King County along I-5 north of the Seattle city limits, Spokane near the east city limits along I-90, and the southeast section of Puyallup along SR 512. Because of the lack of an adequate control area for the Spokane study, only the other three areas were used for the benefit estimation.

It was found that where there was a substantial improvement in the accessibility of an area due to the highway improvement, property values appreciated significantly more rapidly. In Kingsgate I-405 resulted in a 12 percent appreciation, while in the north King County study the appreciation was 15 percent. In both these areas, most residents used the highways for commuting to work and realized significant time-savings. On the other hand, in Puyallup few of the residents used SR 512 for commuting, so there was little or no effect of highway benefits on property values.

Unfortunately, some of the houses closest to the highways also suffer some negative effects because of adverse environmental influences. It was shown that highway noise levels caused a partially-offsetting decrease in property values for those houses closest to the highway. This effect increased as the noise level increased above that in the surrounding neighborhood. The magnitude of this effect ranged from zero to 7.2 percent in the areas studied, depending on the noise level and the character of the neighborhood involved. It was found that as incomes increase, people are willing to pay more for quiet surroundings and thus noise damages increase.

The net effect of these adverse and beneficial influences was positive for the areas where both effects could be quantified. This means that all houses in the areas appreciated because of the highway, but those closest to the highway did not appreciate as much. In Puyallup there were so few houses experiencing highway noise that the effects could not be measured, but since there was little appreciation due to accessibility, the net effect for those few houses might have been negative. A related study was done on the length of time involved in selling properties next to the highway and further removed. There was no statistically significant difference in the selling times in the two locations.

A study of commercial-industrial property values was done in Bellevue along I-405 near the Bel-Red Road. Values were found to have appreciated almost 17 percent more than in a control area that was uninfluenced by highway change. Interciews in this area showed that the managers of the firms in the area were, for the most part, well aware of the benefits provided by the highway. The owners of land in the area tended to underestimate the appreciation in property values due to the highway.

Interviews were also carried out in residential areas. In general, peoples perceptions of both the benefits and adverse effects of the highway were fairly accurate. However, those people living closest to the highway were not as aware of beneficial effects of the highway, and these people also estimated that the negative effect of noise on property values was almost twice as large as it actually was.

Methodology

There are numerous different causes of property value changes when a highway is constructed. These various effects can work in opposite directions and can occur over different areas and times. In this study the beneficial effects are measured by examining the property value trends in the affected area from considerably before the highway's opening to the present. These trends are then compared with a general residential real estate index for comparable property or an index in a control area to discover any differences. The trends within the study area are first established by using hedonic regressions to separate the value of a house into the value of the various components of that house. Once this is done, it is possible to establish the price trends when all the characteristics of a house are kept constant. The accuracy of the price index developed by this method depends on the accuracy of the specification of the regression equation which establishes the component prices. The specification used in this study avoids several problems which have hampered some of the studies which have been done recently. Nonetheless, it was desirable to check the specification of the regression equation by comparing the index generated with an index created by a different method. Such an alternative method was provided by examining repeat sales on the same houses. By this means the various characteristics other than depreciation were constant, and the pure price changes could be measured. The two indexes were then compared to assure the reliability of the price index for the study area. These indexes were then compared with a control real estate price index to see if the highway had influenced the values of nearby homes. It was found that an improvement in accessibility due to new highway was reflected in an increase in property values. A substantial increase in accessibility for the area raised property values by 12 to 15 percent.

A less desirable effect on property values is created by adverse highway influences which may affect certain houses. Noise is the most important of such adverse effects. Noise monitoring was done throughout the study areas. Using this data, the hedonic regressions revealed that property values were hurt by noise. An alternative means of estimating property value damages without noise measurement is carried out using more easily collected data on distance and elevation with respect to the highway and vegetative cover. The negative effects on property values must be compared with the positive effects of improved accessibility to discover the net effect.

Study Areas

A number of criteria were used in selecting the residential study areas. Areas having a large number of houses in close proximity to a limited access highway were considered essential for this study to enable assessment of any negative environmental effects. Also, it was desired that the houses be distributed so that they extended back from the highways about one mile. By utilizing such areas, some houses are adjacent to the highway while others are sufficiently removed that they do not experience any negative effects but do enjoy accessibility benefits. To increase the reliability of the hedonic regressions, the houses should be single-family dwellings and relatively homogeneous. The houses should not be influenced by non-highway negative environmental effects. The highways should have been opened fairly recently but should have been open long enough to allow property values to reach equilibrium. The study areas should lie within a single political jursidiction in order to avoid possible fiscal differences that may affect property values.

The first study area selected was in King County, on the east side of Lake Washington. This area, which is frequently referred to as the Kingsgate area, is located just north of the communities of Kirkland and Redmond and just south of Bothell. It is traversed by Interstate 405 with this section being opened to traffic toward the end of 1970. The study area is bounded by NE 160th Street and NE 132nd Street on the north and south and by 132nd Avenue NE and 100th Avenue NE on the east and west. The direct distance of the houses from the nearest lane of traffic on I-405 ranges from a minimum of less than 100 feet to a maximum of 5,900 feet. There is an interchange at NE 160th Street, the north boundary of the study area, and at NE 124th Street, just south of the south study area boundary. The minimum street distance of a house from the nearest interchange is 2,000 feet, while the maximum distance is 11,000 feet. The gently rolling terrain varies a little over 200 feet in elevation but with no undevelopable steep slopes. Some of the houses are completely exposed to the highway, while others are screened by stands of trees. The area is predominantly occupied by single-family dwellings in the middle to upper-middle price range. The oldest houses in the platted areas studied were built in 1962, while the major building expansion was begun in 1965.

All valid sales between 1962 and July 1976 were obtained. This provided a data base of 4,785 sales for the analysis. The sales prices varied from a minimum of $11,800 to a maximum of $57,000, but since there has been considerable inflation of real estate prices in the fifteen years being studied, it is necessary to deflate these figures to get the prices in constant dollars. Using the Seattle Real Estate Research Committee's market price index, the prices were obtained in 1967 dollars. In this case the mean price was $23,012 with a range from $11,064 to $33,728.

The second study area which was utilized bordered Interstate 5 north of Seattle. This relatively homogeneous lower-middle class neighborhood contains homes that average 25 years old. Interstate 5, which in this section has six through lanes with two more lanes in connection with exits or entrances, was opened in late 1965. Thus, most of the houses were built before the highway location was announced.

The area borders the highway from the north city limits of Seattle north approximately three miles to the Snohomish County line. The area is bordered by NE 145th St. and NE 205th St. on the south and north respectively and by Meridian Ave. N. and 15th Ave. NE on the west and east respectively. The distances of the houses from the highway ranged from less than 100 feet to 1900 feet. Although there is some undeveloped land in the area, the study was restricted to platted land with single-family residences. Highway access is provided at either end of the study area and at NE 175 St. As in Kingsgate, the terrain is gently rolling with less than 200 feet of elevation difference.

All valid sales beginning in 1958 and continuing through 1976 were collected, which yielded a data base of 2,823 observations. The nominal prices ranged from $4,950 to $58,950 with a mean of $18,568. When the prices were deflated by the Seattle real estate market price index, the real prices in 1976 dollars ranged from $4,274 to $46,635 with a mean of $17,495.

Another study area was selected along Interstate 90 through Spokane. Here a major urban freeway passes through an area of older houses that were built long before the highway was opened. The average age of the houses is fifty years, while the highway was opened in early 1959 to carry the traffic that had previously used Sprague Avenue. This was only one of a number of changes that may have affected property values in this area over the years. Nonetheless, this area of lower-class homes provided an increased range of socio-economic neighborhoods being studied.

The study area is just inside the east city limits of Spokane and south of Interstate 90. It is bordered on the east by Havana St. and on the west by Pittsburg St. Interstate 90 forms the north boundary, and the area goes south to Hartson Ave. This is the only residential study area that did not include houses on both sides of the highway. This is because houses north of the highway are within close proximity to Sprague Avenue which is lined with commercial establishments. Additional stores are located throughout the area. Since such an area did not meet the requirements of a relatively pure residential area without incentives for speculation on use change, it was not included in the study area. On the south side of the highway the study area only went back from the highway a maximum of 1300 feet because a steep hillside forms a natural southern boundary. A total of 745 observations were available for this study area.

The final residential study area to be discussed is located in the southeast corner of Puyallup where SR 512 has recently been built. Much of this area is still relatively undeveloped with farm land or small residential acreages scattered among the more densely developed residential areas. The northwest part of the study area is older and more uniformly developed than the rest of the study area. SR 512 is a limited-access four lane highway that was opened in December of 1973. One of the main reasons for the study was to examine whether or not the houses located to the southeast of the highway appreciated more slowly because they had been isolated from the main part of the city. This was a concern that was frequently expressed prior to the construction of the highway.

The study area was bounded on the north by Pioneer Avenue, on the west by 16th Street SW, on the south by the Puyallup city limits, and on the east by 9th Street SE and 17th Street SE. A control area was also used which was bounded by the railroad tracks (Stewart Avenue) on the north and Pioneer Avenue on the south. Many of the residents of Puyallup work in the Tacoma area and commute by way of the River Road (SR 410) which joins I-5 east of Tacoma. After leaving Puyallup, SR 512 turns west and joins I-5 south of Tacoma, but it is not often used for commuting according to the residents.

Sales were collected which took place between 1965 and 1976 inclusive. This provided a data base of 838 sales. The mean price was $17,345 with a range from $2,877 to $66,000. When the prices were deflated by the consumer price index, the mean was $13,787.

Data Collection

For all four of the residential study areas, data collection centered around the real property records of the county assessor's office. This source provided a wealth of information on the characteristics of the land and structures being studied. In addition the assessor's records contained information on the sales that had taken place on each particular piece of property. In King County there was also an even better source of information on sales prices and dates since the one-percent excise tax on real estate transactions is cross-indexed by location in that county. The remaining data were collected directly through the use of assessor's maps and visits to the site.

One of the more important variables is a measure of the highway noise levels at the houses. Noise monitoring was done at various distances from the highways, at different elevations with respect to the highways, and with varying vegetation covers. At least three readings were taken at each station during peak traffic hours. The mean of these readings was then recorded on assessor's maps. This information was used to construct contour lines representing equal noise levels.

Access Benefits

The data on prices, sales dates, and property characteristics were used to develop real estate price indexes for the study areas to measure access benefits. To assess the impact of the highway upon property values, it was necessary to know the general trend in real estate prices during these years. Within King County the Seattle Real Estate Research Committee computes price indexes for single-family residential properties in various areas. In Puyallup a control area was used.

The SRERC index for properties on the eastside of Lake Washington was most comparable for the Kingsgate area. Properties in this area were approximately the same distance from Seattle and the same age as those in the study area. Only a small fraction of the houses on the eastside were affected by major highway changes during that time. After the opening of I-405, the properties affected by the freeway appreciated in value at a considerably faster pace than average properties on the eastside of Lake Washington. Between the opening of the highway and 1975, the houses in the study area appreciated an average of 12 percent more than houses elsewhere on the eastside. In 1976 the average sales price of houses in the study area was $36,787. Applying the indexes to this mean value shows that average house was worth $3,941 more than if it were located away from access to a major highway. The full effect of the highway did not seem to take place immediately but rather property values increased over several years. Also, property value increases do not seem to anticipate the opening of the highway. These two indexes are reproduced in Table 1. The highway opened in 1971, and the indexes are normalized on that year.

In the Kingsgate area, I-405 provided a substantial increase in accessibility to points north and south as well as to Seattle by way of the Lake

Washington bridges. The resultant time-savings resulted in the appreciation of property values by 12 percent. Tests show this to be best expressed as a percentage of the house value rather than an absolute amount applying to all houses.

TABLE 1

Comparison of Kingsgate Index and Eastside Index

Year	Kingsgate Study Area Resale Index	Eastside Index
62	.731	.719
63	.737	.727
64	.786	.743
65	.778	.760
66	.829	.785
67	.908	.826
68	.958	.876
69	1.025	1.008
70	1.010	.975
71	1.000	1.000
72	1.053	1.016
73	1.129	1.066
74	1.231	1.132
75	1.367	1.181
76	1.490	1.322

Similar techniques were used to develop a real estate price index for the north King County study area. The Seattle Real Estate Research Committee has an index representing real estate trends in north Seattle, north King County, and southern Snohomish County. This index represents the general location and type of homes in the study area. This control index is reported in Table 2, along with the index for the highway study area. Both have been normalized in 1965, the year the highway was opened. It can be seen that the two indexes track together very well in the years before the highway was opened. After the highway, homes near the highway appreciated considerably more rapidly than those represented by the control index. There was a dip in the resale index between 1969 and 1973. This aberration is easily accounted for since these are the years of the Boeing Company reductions in unemployment. Many Boeing Company workers choose to live in areas such as Kingsgate and this north King County area because these locations are central between Everett and Renton where this company has plants.

Such houses command a premium because of the accessibility which the highway affords. When Boeing cut its employment by well over half and there were substantial secondary employment cuts, many of the residents of such areas were forced to sell, and the premium for accessibility was reduced. After the slump the differential was reestablished. The differential, with the exception of the years of the downturn, appears to have been about a fifteen percent appreciation because of the accessibility benefits. This appreciation does not appear to have taken place on the announcement of the highway but rather upon the opening of the highway. The improvement in accessibility in this area was comparable to that in the Kingsgate area. The

TABLE 2

Comparison of I-5 North King County Index
with Control Index (normalized on highway opening, 1965)

Year	I-5 North King County Index	Control Index
50	.923	.94
60	.919	.95
61	.974	.96
62	.983	.98
63	1.017	1.00
64	1.017	1.00
65	1.000	1.00
66	1.056	1.01
67	1.222	1.05
68	1.375	1.15
69	1.432	1.31
70	1.403	1.33
71	1.370	1.34
72	1.452	1.39
73	1.467	1.44
74	1.656	1.47
75	1.864	1.62
76	2.155	1.76

same destination to the north and south are available, and similar time savings are allowed by the highway. It is encouraging that the results in the two areas are quite close.

For study areas outside King County, indexes such as those estimated by the Seattle Real Estate Research Committee are unavailable. In the Puyallup study area the index derived was compared with a county-wide index based on mean sales prices and with the trends in a control area in Puyallup. Both techniques indicated that, while study area properties may have appreciated slightly more rapidly than the control indexes, there was no statistically significant difference. This coincides with the interview data where few of the residents indicated using SR 512 in commuting to work. Since the time savings for residents would thus be small, it is not surprising that the property value effects were not large.

The results from these study areas seem to indicate that improvements and accessibility and time-savings can be reflected in residential property values. However, the magnitude of this effect depends very much on the magnitude of the improvement in accessibility, especially with respect to work trips. Where the improvement was substantial, such as when I-405 or I-5 were opened, property values increased by 12 percent or more. But when few of the residents saved time in their commuting trips, as with SR 512, property values appreciated little if at all because of the highway. In making forecasts of the effect of a change in the highway system, the accessibility improvement must be estimated. The forecast could then be estimated as equal to that in the study area with a comparable improvement or as an interpolation of the results in two study areas if the improvement lies between that in the two study areas.

Noise Damages

In addition to the access benefits described above, the residential studies also allowed estimation of any negative proximity effects. The measured noise levels were used to assign a noise reading to each house as described above. The effect of this noise on property values was then isolated from the effects of other differences in properties. There was sufficient noise data to obtain this estimate for Kingsgate, north King County, and Spokane. The results are summarized in Table 3.

Tests indicated that in each of the study areas the effect of noise was best expressed as a percentage of the value of the home rather than a fixed, absolute amount. In addition tests were performed to examine whether or not a given increase in noise has the same effect at different noise levels. The A-weighted decibel scale was designed to approximate human perception of noise, but it is possible that it might not approximate the level of annoyance caused by that noise. Alternative forms for the noise variable were tried, but the linear form proved superior in all three study areas.

The percentage reduction differs in each of the areas, but this is an expected outcome rather than a weakness in the study. Because the housing was already in existence when the highway was constructed in each of the areas, the class of housing differs between areas. As a result, the incomes of the residents also differ. It might well be expected that wealthier individuals would be willing to pay more for quiet in their residences. The studies confirm this since not only are the damages a percentage of the value of the house, but also the magnitudes of the percentages increase with increasing income. The results of this study could be used to forecast the effect in an area where a new highway was proposed. One would determine the income in this new area in 1970 dollars and find the relation to the incomes in the study areas. One could then interpolate between the relevant estimates to determine the anticipated percentage reduction in property values due to the new highway.

To estimate the overall effect of a highway on property values, one must consider both the access benefits and adverse noise effects. Table 4 summarizes the maximum noise damages for each of the areas. In Kingsgate the 12 percent appreciation due to accessibility improvement more than offsets the

TABLE 3

Property Value Depreciation due to Highway Noise

for different areas

Area	Average House Price (1976 Dollars)	Average Income (1970 Census of Population)	Percent Reduction for $2\frac{1}{2}$ dBA Increase in Noise Level above Ambient	Dollar Reduction for Average House for $2\frac{1}{2}$ dBA Increase in Noise Level above Ambient (1976 dollars)
Kingsgate	$39,244	$14,076	1.2%	$470.82
North King County	$29,834	$12,890	.75%	$223.70
Spokane	$14,617	$ 8,943	.20%	$ 29.23

TABLE 4

Maximum Property Value Depreciation at Highest Observed Noise Levels

for Different Areas

Area	Highest Noise Reading	Percent Reduction from Ambient	Dollar Reduction from Ambient for Average House
Kingsgate	70 dBA	7.2%	$2824.95
North King County	75 dBA	6.0%	$1789.64
Spokane	80 dBA	2.0%	$ 292.27

7.2 percent reduction due to noise at the noisiest houses. For the average house in 1976 dollars these figures are $4,709.28 appreciation and $2,824.95 noise damages for a net effect of $1,884.33. In the north King County study area the two percentages are 15 percent appreciation and 6 percent noise damages. The average value house would experience $4,475.10 appreciation and $1,789.64 noise damages for a net appreciation of $2,685.46. These figures only apply to the noisiest houses, and those experiencing less or no noise would receive larger net benefits. One area where this trend may not hold is Puyallup. Because the access benefits are quite small it is possible that the few houses experiencing substantial noise would experience a negative net effect on their property values. This does not suggest that the overall project did not have positive net benefits, but a few households may have been hurt. Judging by the highways studied, this situation is the exception. Generally, even those properties experiencing significant noise tend to appreciate if there is an improvement in accessibility, although by significantly less than similar properties not experiencing the noise but enjoying the accessibility improvement.

Commercial-Industrial Study Area

It was also desired to study the effects of a highway on property values in a commercial-industrial area. It was much more difficult to find acceptable study areas for this portion of the study for several reasons. First, commercial-industrial establishments generally have such definite transportation requirements that it is almost impossible to find such areas where there is not good access. This makes it quite difficult to find a study area that antedated the construction of a highway.

It is also necessary to control for the difference in the structures on the land to isolate the highway effects. With residential properties this was done by recording the various characteristics that individuals consider in making a home purchase and using hedonic regressions to isolate the desired effect. The same technique might be used with commercial-industrial properties, but the desired characteristics vary significantly with the types of of businesses. This makes the specification of the hedonic equation considerably more difficult than in the residential case. In addition the data on characteristics are quite difficult to obtain because of confidentiality considerations. The selected alternative was to find an area where there was a mixture of commercial-industrial establishments and vacant land. This portion of the study could then examine trends in undeveloped land prices without considering structural characteristics. Interviews with established firms were also done to find the owner's perceptions of the effect of the highway. However, this mixture of vacant and developed land is uncommon in commercial-industrial areas, making study site selection difficult.

A final problem is the lack of commercial-industrial real estate price indexes to serve as a control. For this reason an actual control area was necessary. Unfortunately, this area also had to have a mixture of undeveloped and developed land to be useful. It also had to be relatively close to the study area in terms of distance and character.

The study area which seemed to best meet these restrictive conditions was in Bellevue, east of I-405. This section of I-405 was opened in June, 1972, but there were already commercial and industrial establishments in the study area at this time. The irregular study area is roughly divided in two sections. The northern segment runs from Northrup Lane on the north to NE 8th Street on the south, and between 116th Avenue NE and 140th Avenue NE on the west and east respectively. A portion of the area continues south from NE 8th Street to SE 5th Street between 112th Avenue NE and 120th Avenue NE. These combined sections contain Benroya Business Park, the numerous automobile dealers 116th Avenue NE, and the extensive commercial development along the Bel-Red Road. Safeway and Coca-Cola are the two largest establishments in the area in terms of both area and dollar volume. Most of the manufacturing businesses are located in the northern part of the study area. Much of the northwest portion of the study area is served by several railroad sidings to the Burlington Northern line. A substantial amount of vacant land remains throughout the area.

The control area selected was further south along I-90. This Interstate highway provides transportation access to the area, but there were no major changes in the highway during the period studied. The control area extends from I-90 on the south to SE 26th Street on the north, and from 128th Avenue SE to 148th Avenue SE on the west and east respectively. It is similar in character with small shopping centers, light industry, and vacant land.

Because of confidentiality restrictions, data on sale prices and dates were collected from the monthly publications of Monitor Real Estate Corporation of Seattle rather than the assessor's records. Monitor records all sales in King County for which the legally-required excise tax is paid. Sales are classified by type of zoning and vacant or nonvacant land. All sales of vacant land within the study and control areas between 1965 and 1977 inclusive were collected. This provided 268 observations. Zoning information was obtained from the Bellevue Planner's Office, and land areas and access information were obtained from assessor's maps. A majority of the land was zoned for either manufacturing or for retail-wholesale use, although there were three other general classifications that accounted for approximately 20 percent of the sales. There was a wide range of land areas from about 20,000 square feet to over 650,000 square feet.

After controlling for parcel size, zoning, railroad and street access, and the year of sale, the properties in the study area were shown to have appreciated significantly more than those in the control after the highway was opened. In fact, the differential was 16.7 percent. The improved access for incoming goods and customers for the commercial establishments and incoming and outgoing goods for manufacturers and warehousing provides the motivation for the firms location here. This results in the appreciation of property values. Noise did not appear to have any adverse effects on these properties. As before, in using these results for forecasting the effects of a new highway on property values, one must consider the degree of accessibility improvement that is anticipated.

Length of Time on the Market

The studies described previously have established that in some areas property values have been increased by highway access, but this has been partially offset by highway noise and possibly by other negative proximity effects within the area closest to the highway. The amount of this partial reduction has been quantified. It is possible that, in addition to this price effect, highway proximity might increase the average time on the real estate market for houses in the impact zone. Such a possibility was expressed as a fact by almost half of the residents of the impact zone who were interviewed.

To test this, data were necessary on the length of time houses within an area studied were on the market. Such information was provided for the Kingsgate area by the Cumulative Street Index File, January 1974 through June 1976 issued by the Eastside Brokers Association. This publication by a multiple listing service provides information on all residential listings by member firms during the period indicated. This represents over 80 percent of the houses that were on the market in that area. All market listings on single-family residences within the study area were selected. Data were collected on the initial listing price, the selling price, the number of days on the market, the terms of the sale, the end date of the listing, and the status of the property. The status of the property referred to whether the house had been sold, withdrawn from the market by the owner, or inactive during the time period covered, or if the listing had expired. The data provided 1,170 cases of which 64 were on houses in the impact zone within 600 feet of the highway. Of these 1,170 cases, 895 were sold, 169 expired, 81 were withdrawn, and 25 were inactive at the end of the dates covered.

The first tests run concerned comparisons of the mean number of days on the market for different subgroups of the market. The results are reported in Table 5. Of these properties which sold, the ones close to the highway averaged about seventy days on the market, while those more removed averaged about 81 days. For properties which were not sold in the period covered, the number of days on the market averaged about 75 days for the impact area and about 96 days for the study area. The relationship in both these pairs runs counter to the beliefs expressed by many residents. Statistically the difference is negligible.

TABLE 5

Statistics on Days on the Market
for Various Subgroups

Population	Mean	Variance	Number of Cases
All properties on the market	84.177	5753.848	909
Properties which sold	80.352	4767.445	674
Impact area	69.667	2188.292	33
Study area	80.902	4897.660	641
Properties which did not sell	95.149	8452.355	235
Impact area	74.929	848.225	14
Study area	96.430	8912.445	221

There is a slight tendency for a listing on a house in the impact zone to expire or be withdrawn but this tendency is statistically insignificant. Further tests of association show that there is no relationship between the distance to the highway and the terms of the sale or the date of the sale. There is strong association between the length of time on the market and the terms of the eventual sale since the less desirable terms are generally used after the house has remained on the market for a period of time. But the distance to the highway does not affect this choice of terms. There are also cycles in the real estate market, but the distance to the highway does not affect any cyclical movements. The houses in the impact zone do not seem to be more strongly hit by a downturn, although data over a longer period of time would provide a more powerful test of this theory.

All evidence points to any negative effects of the highway on adjoining properties taking the form of price changes. It does not appear that highway proximity has any effect on the length of time involved in marketing a house.

Interviews

Another phase of the study involved personal interviews with the residents to discover their perceptions of the beneficial and adverse effects of having a major highway located nearby. The effects that they perceived were then compared with the effects revealed by the real estate market.

These interviews were conducted in person by a team of interviewers. This method was selected in order to obtain the desired high return rate and insure hearing the opinions of those residents who were disgruntled with the highway. It was desirable to have any residents present who commute to work and where possible to have both husband and wife present. For these reasons, a majority of the interviews were conducted on weekends and at night. Attempts were made to interview at least one adult in every house which abutted the highway and in a sample of houses more removed from the highway.

The first set of interviews was done in the Kingsgate area where 240 interviews were conducted, 114 at abutting properties. The major portion of the interviews concerned potential beneficial and adverse effects of the highway on the residence. The first questions of this part referred to the awareness of highway benefits. The distribution of responses to the general question, "Are there benefits to you from having a highway nearby?" was quite revealing. In the impact area within 600 feet of the highway the interviewers explained that this question referred to benefits from having the highway in the area and not necessarily from having it within 600 feet. In spite of this clarification, impact zone residents reported benefits less frequently than those living in the study zone more than 600' from the highway. In the impact zone 82.5% felt there were benefits, which seems a substantial proportion until it is compared with the study zone where 99.2 percent mentioned benefits. Since the locations of work and distance to highway access did not differ substantially between the areas, it appears that the same benefits were present for the two groups. Yet the adverse effects in the impact zone were preventing approximately one-fifth of those interviewed from being aware of such benefits.

The next questions in the interview concerned perceived adverse effects. The questioning was divided into two parts. First, people were asked which adverse effects, if any, they noticed, and then they ranked the importance of these effects. For this part of the interview no suggestions of possible effects were made by the interviewers. Secondly, the respondents were asked to evaluate the importance of effects suggested by the interviewer. Questioning here concerned the effects both inside and outside the dwelling.

The results from the first part were reported for the entire sample in Table 6. Noise was the one adverse effect mentioned extensively. Within the impact zone approximately three-fourths of those interviewed cited noise as the most important adverse effect. Those further removed from the highway in the study area still mentioned noise in one-fourth of the cases. Air pollution was the other problem mentioned with the next greatest frequency, but noise was mentioned almost ten times as often.

The questions to this point only revealed which effects were mentioned and not the relative severity of the problems. The next part of the interviews sought relative evaluations of the different effects. The results are reported in Table 7. The first point about these responses is that the highway seems to have few adverse effects for those residents more than six hundred feet from the highway, which agrees with the noise monitoring results reported earlier. Only one respondent found any of the effects annoying inside the home. Less than 16% even noticed the noise, and they did not find it annoying. Outside the home the results were comparable except for noise where about five percent now found the noise annoying. Thus it appears that the measure of the adverse effects used earlier in this study coincides fairly well with the responses.

The responses in the impact zone were perhaps surprising in that many people did not find the effects annoying. Inside the houses only about five percent of the residents found effects other than noise to be annoying or objectionable. Within the house 16.7 percent found the noise annoying and 3.5 percent found it objectionable. The most respondents found the effects other than noise 'not noticeable' and noise 'noticeable but not annoying'. Outside the home the effects were more important. The noise was annoying or objectionable to 35.1 percent of those interviewed, and seven percent felt that way about air pollution. The other effects were perceived to be the same as indoors.

TABLE 6

Adverse Effects Voluntarily Mentioned and Ranked in the Total Sample

Number of People Giving Ranking

	1	2	3	4	5
Noise	117(48.7%)	1(0.45)			
Air Pollution	5(2.1%)	8(3.3%)			
Lights					
Vibration	3(1.2%)	1(0.4%)	2(0.4%)		
Visual Effects	4(1.7%)	2(0.4%)		1(0.4%)	
Other[1]/	28(11.7%)	3(1.2%)	1(0.4%)		1(0.4%)

1/ Most of the other effects mentioned involved issues that were specific to this section of highway, such as the existence of a gravel pit that was an attraction for children. Two families felt that the highway separated them from friends or relatives living on the other side which is an effect that might be present on any segment of highway.

TABLE 7

RESPONSES IN THE IMPACT ZONE (within 600 feet of the highway)

How would you describe the overall effect of these highway disturbances?

A. Inside your home:

	Objectionable (4)	Annoying (3)	Noticeable But not Annoying (2)	Not Noticeable (1)
Noise...........	4(3.5%)	19(16.7%)	52(45.6%)	39(34.2%)
Air Pollution...	3(2.6%)	4(3.5%)	8(7.0%)	99(86.9%)
Lights..........			3(2.6%)	111(97.3%)
Vibration.......	2(1.8%)	3(2.6%)	4(3.5%)	105(92.1%)
Visual Effects..	2(1.8%)	3(2.6%)	5(4.4%)	104(91.2%)

B. Outside your home:

	Objectionable (4)	Annoying (3)	Noticeable But not Annoying (2)	Not Noticeable (1)
Noise...........	25(21.9%)	15(13.2%)	47(41.2%)	27(23.7%)
Air Pollution...	5(4.4%)	3(2.6%)	10(8.8%)	96(84.2%)
Lights..........			4(3.5%)	110(96.5%)
Vibration.......	2(1.8%)	3(2.6%)	5(4.4%)	104(91.2%)
Visual Effects..	2(1.8%)	3(2.6%)	5(4.4%)	204(91.2%)

TABLE 7 (Cont'd)

RESPONSES IN THE STUDY ZONE (more than 600 feet from the highway)

How would you describe the overall effect of these highway disturbances?

A. Inside your home:

	Objectionable (4)	Annoying (3)	Noticeable But Not Annoying (2)	Not Noticeable (1)
Noise.............		1(0.8%)	20(15.9)	105(83.4%)
Air Pollution.....		1(0.8%)		125(99.2%)
Lights............			1(0.8%)	125(99.2%)
Vibration.........		1(0.8%)		125(99.2%)
Visual Effects....		1(0.8%)		125(99.2%)

B. Outside your home:

	Objectionable (4)	Annoying (3)	Noticeable But Not Annoying (2)	Not Noticeable (1)
Noise...........	1(0.8%)	6(4.8%)	33(26.2%)	86(68.3%)
Air Pollution...		1(0.8%)	1(0.8%)	124(98.5%)
Lights..........			1(0.8%)	125(99.2%)
Vibration.......		1(0.8%)		125(99.2%)
Visual Effects..		1(0.8%)		125(99.2%)

The interviews then had the residents evaluate the beneficial and adverse effects together to find an overall rating of the highway's effect on their living conditions. The results for the different groups are reported in Table 9. For the entire sample the median and the mean of the responses were in the category 'good'. In the study area the most common response was 'very good', while the mean was half way between 'very good' and 'good'. In the impact area the most common response was 'good', but the mean was between 'good' and 'neutral'. There is a statistically significant correlation between measured noise level and overall highway rating, so noise is an important factor in people's evaluation of the highway. It is of special interest to note that those people who bought their houses without knowing of the plans for the highway rated the highway significantly worse ("bad" was the most frequently given answer) than those people in the impact zone who bought their houses knowing of the plans.

TABLE 9

Residents' Overall Rating of the Freeway on Living Conditions

	VERY GOOD	GOOD	NEUTRAL	BAD	VERY BAD
Study Zone	62(49.2%)	52(41.3%)	11(8.7%)	1(0.8%)	
Impact Zone	11(9.6%)	47(41.2%)	33(28.9%)	21(18.4%)	2(1.8%)
Total Sample	73(30.4%)	99(41.3%)	44(18.3%)	22(9.2%)	2(.8%)

The part of the interviews which related most closely to the main body of this research concerned the perceived effects of the highway on property values. In the study zone, 46.8% felt that the highway had increased their property values compared with what they felt would have happend if the highway had not been constructed. No effect was expressed by 37.3%, while less than 2% felt that property values had been decreased by the highway. In the impact zone, 36% felt values had been hurt, 31.6% thought there was no effect, and only 13.2% thought there was no effect, and only 13.2% thought they had increased. Next the residents were asked if they could estimate the dollar value of these property value effects. Only about two-thirds expressed their opinions, but this was a high enough response rate to allow some generalizations. The residents believed that the damages were approximately twice as large as those found in actual sales. This indicates that in evaluating highway impacts it is important to consider not only the anticipated actual effects on property values, but also the anticipated perceptions of those effects.

Interviews were also conducted with the residents of the Puyallup study area. In many respects the results were quite comparable to the results in Kingsgate. Noise considered to be by far the most significant adverse effect, and once again people's ratings of the adverse effects correlated well with the actual noise readings. However, few of the people interviewed used SR 512 in commuting to work. Thus, the evaluation of the benefits of the highway was significantly lower than in Kingsgate. This fact also lowered the overall ratings of the highway in Puyallup.

As part of the Bellevue commercial-industrial study, the managers of a representative sampling of business firms were interviewed. A majority of the interviews were at retail establishments, but interviews were conducted with all the large wholesale and manufacturing establishments. A majority of the firms chose to locate in the area because of transportation availability or customer accessibility. Over 72 percent of those interviewed felt that I-405 helped customer accessibility, and 45 percent felt it improved goods accessibility for their firm. Over 65 percent stated that highway use had increased the gross sales of the firm, and 55 percent thought that the highway also resulted in lower operating costs. A significant number of firms (27.6 percent) indicated that they would not have chosen to locate in the area if I-405 had not been in existence. The overall rating of the highway was between good and very good, and a majority of the firms felt that the effect had been major.

To examine people's perceptions of the effect of the highway on property values, interviews were also conducted with the owners of vacant land in the area. Half of these individuals felt that I-405 had influenced the value of the property. Although there was great uncertainty as to the magnitude of this effect, the estimates averaged 7.5 percent which underestimates the actual effect estimated from real estate sales. These individuals felt that the increases could be attributed for the most part to improved customer and employee accessibility.

Applications

The possible applications of these results are many. The most important use is in connection with impact statements and public involvement programs. This application provided the original motivation for the study. The results of this study have quantified the property value effects of a limited-access highway. This information can be utilized for generally assessing property value effects in similar locations when a highway is constructed. Property value effects are a great source of public concern. This evidence will provide facts for detailed discussions on this topic.

There has been substantial interest in partially financing highway construction by capturing part of the accessibility benefits through property taxes. The property value effects are caused by the user benefits from the highway, and do not represent an additional benefit. If existing taxes on highway users are at an appropriate level then an additional tax on property is not called for. If additional taxes are indicated, they could take either form with similar long-run effects. A choice between the two must be based on short-run distributional effects. A related point is that care must be used in applying the results of the benefit side of this study to benefit-cost analyses. Double-counting would result if user benefits were fully evaluated and property value effects were added.

These same considerations do not apply to the adverse property value effects of noise. Noise represents an externality which must be considered in benefit-cost analysis in order to make efficient decisions. The distributional effects of these externalities might also be important in evaluating a proposed highway.

Finally, this study might prove useful in making decisions between various transportation modes. Such a choice between modes must be based on all of the effects of the construction of each mode.