

TIME-SERIES EFFECTS OF A LIMITED-ACCESS HIGHWAY ON RESIDENTIAL PROPERTY VALUES

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The purpose of this paper is to illustrate use of a method for constructing property value price indexes to assess the effects over time of a limited-access highway on residential property values. The community of North Springfield, Virginia, which is bisected by I-495, was selected for study. Each property was initially categorized as being in the abutting, impact, or nonimpact zone, depending on its distance from the highway. A multiple regression procedure incorporating sale and resale values of properties from 1962 to 1972 was used to construct 3 separate time series of index numbers (one for each property category). For each year in the relevant period, differences among the index numbers were tested for statistical significance. The comparisons for the year 1962 to 1969 did not indicate any significant differences among index numbers. For 1970 to 1972, however, properties nearer the highway generally exhibited index numbers that were significantly lower than those of more distant properties. In terms of effects on property values, the study conclusively showed that, during the more recent years of the time series, North Springfield properties located in proximity to the highway failed to increase in value at rates equal to those of properties located farther from the highway.

•A limited-access highway confers economic and social benefits on some portions of society and economic and social losses on others. Benefits accrue when users of the highway travel with greater efficiency and comfort and enjoy better accessibility to both regional and local destinations. Benefits may also accrue to those people who do not use the limited-access highway. These benefits take the form of reduced traffic congestion on the highways (particularly those in urban areas) that they do use. In addition, users and nonusers alike benefit when prices of goods and services are lower than they would be without the limited-access highway.

Some interests benefit from a new limited-access highway in another way. A major highway can significantly increase the values of properties at interchange sites, but many costs are also incurred when a new highway is built (22). In addition to the direct costs of acquisition of rights-of-way, construction, and maintenance, many indirect costs may occur. There often is a loss of tax base, the highway may create the need for increased levels of community services such as police and fire protection, and there may be indirect negative effects on business and industry not close to the highway. All such indirect costs must be provided for in the economic and fiscal structures of an affected community or municipality, or they must be absorbed privately.

A limited-access highway adjacent to a residential community has been strongly suspected to have adverse effects on the quality of life experienced by residents of abutting and near-abutting homes and to lower property values as a result. This notion was substantiated by in-depth cross-sectional analyses of 1970 residential property sales data from four suburban communities that were bisected by limited-access highways (8, 9, 10). Adverse highway effects such as noise and air pollution were perceived by a predominant number of residents of the North Springfield, Virginia, study site and were scientifically detected and measured at distances of up to 900 to 1,150 ft (274 to 350 m) from I-495. Properties abutting the highway were sold in 1970 for an average of \$1,518 less than comparable properties farther removed from the highway. I felt that such a cross-

sectional analysis was valuable but that a time-series analysis of property value changes in North Springfield might supplement the existing findings and provide a comprehensive description of the nature of such adverse effects on property values. There are 3 study objectives:

1. To describe a method that allows transportation planners to efficiently construct a time series of property value index numbers that may be used to describe the behavior of aggregate property values over time,
2. To statistically compare time series separately constructed for groups of properties segregated by the characteristic of distance from the highway, and
3. To compare such findings with those previously reported for the North Springfield study site.

Figure 1 shows the location of the North Springfield study site. Average housing value in that area in 1970 was \$33,000. Household heads were predominantly employed in professional and managerial positions and exhibited a 1970 median income of \$17,347. Although the study site can hardly be considered representative of a typical cross section of an American residential neighborhood, this was not of primary concern to satisfy the study objectives. The importance placed on comparing findings with the earlier cross-sectional study was the motivating factor in the selection of North Springfield for purposes of the time-series analysis.

METHODOLOGY OF PROPERTY VALUE PRICE INDEX CONSTRUCTION

This section briefly describes a method set forth by Bailey, Muth, and Nourse (3) by which a time series of property value index numbers may be constructed. The approach has been implemented with regard to other conceivable effects on property values (3, 17, 18), but its presentation here represents its first application concerning highway effects on property value. The years relevant for study were from 1962 (the first full year in which I-495 was opened to traffic in the North Springfield area) through 1972.

Use of the method requires that usable observations be restricted to properties that were sold at least twice during the 11-year period. The method incorporates only sale-resale pairs of property transaction values and minimizes the various quality differences of properties sold in any given year. For each property sold at least twice in the 11-year period, the first step is computation of a price relative for each pair of transaction values. Such computation is as follows:

$$\text{Price relative} = \frac{P_{f,k}}{P_{i,k}} \quad (1)$$

where

$$\begin{aligned} P_{f,k} &= \text{final (year } f) \text{ sale value of property } k, \\ P_{i,k} &= \text{initial (year } i) \text{ sale value of property } k, \text{ and} \\ & i < f. \end{aligned}$$

This ratio is an estimate of the ratio of the true, but unknown, price indexes for years i and j as follows:

$$\frac{P_{f,k}}{P_{i,k}} = \frac{I_f}{I_i} U_{i,f,k} \quad (2)$$

where

I_f = true property value price index for year f (relative to some base year),
 I_i = true property value price index for year i (relative to same base year), and
 $U_{i,f,k}$ = error term or residual.

Taking the logarithm of each side of the equation gives

$$\log \frac{P_{f,k}}{P_{i,k}} = \log I_f - \log I_i + \log U_{i,f,k} \quad (3)$$

Generalizing this equation gives

$$\log \frac{P_{f,k}}{P_{i,k}} = \sum_{j=1962}^{1972} (\log I_j) X_j + \log U_{i,f,k} \quad (4)$$

where $X_j = +1$ for the year of final sale, -1 for the year of initial sale, and 0 for all other years. The method then effectively reduces to a linear regression problem where the X_s are the independent variables, the logarithms of the I_s are the logarithms of the index numbers to be estimated, and the logarithms of the price relatives are the dependent variables.

STUDY AREA SEGMENTATION

For purposes of analysis, the 1,676 properties of North Springfield were classified according to the following scheme (1 ft = 0.3 m):

<u>Zone</u>	<u>Number</u>	<u>Description</u>
Abutting	99	Properties adjacent to I-495
Impact	620	Properties located 1,125 ft or less from I-495
Nonimpact	1,026	Properties located more than 1,125 ft from I-495

All impact zone properties not considered to abut the highway were referred to as proximal properties. Figure 2 shows how the study area was segmented.

It is important to carefully consider the definition of impact zone as used in this study. Two hundred and fifty-four residents of the 1,676 properties were interviewed to determine the extent to which they perceived highway-related disturbances such as noise and air pollution. Analyses of such resident perceptions and actual field measurements of such disturbances indicated that adverse highway effects were concentrated within an impact zone that extended approximately 1,125 ft (343 m) from I-495. Some scattered residents living beyond 1,125 ft (343 m) did report annoyance caused by the highway, but the number and degree of such complaints were not significant.

NORTH SPRINGFIELD, VIRGINIA, PROPERTY VALUE PRICE INDEXES

Property records from Fairfax County, Virginia, were examined to enumerate data concerning all North Springfield residential property transactions from 1962 through

Figure 1. North Springfield, Virginia, study site.

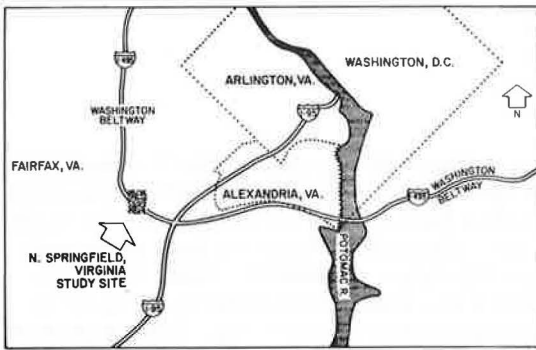
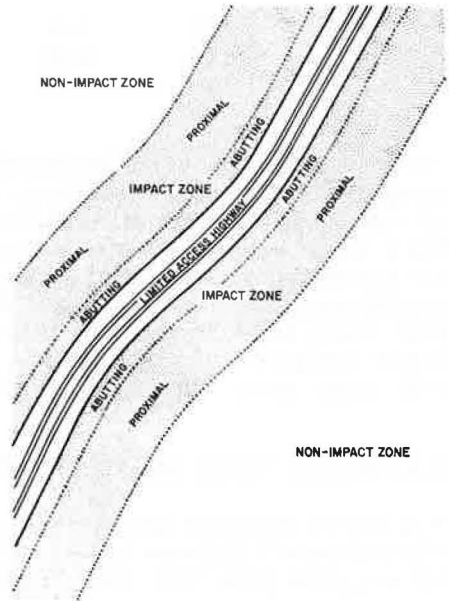


Table 1. Property transfer value pairs suitable for analysis, 1962-1972.

Number of Transfers	Absolute Frequency	Pairs Constructed per Property	Number of Pairs Constructed*
0	565	0	0
1	558	0	0
2	391	1	391
3	128	3	384
4	33	6	198
5	1	10	10
6	0	15	0
Total	1,676		983

*Computed by multiplying absolute frequency by pairs constructed per property.

Figure 2. Relationship between impact and nonimpact zones.



1972. The number of usable (or, more correct, valid) transfers during the 11-year period totaled 1,861; the high was 238 in 1963 and the low was 127 in 1970.

Five hundred and fifty-three individual properties transferred more than once, and the transaction values of those properties constituted the data base for use in the multiple regression procedure. Properties sold more than twice generated more than 1 sale-resale pair of values; therefore, a total of 983 pairs were available for analysis. Table 1 gives the logic underlying this conclusion. Of the 983 pairs suitable for analysis, 388 were relevant to nonimpact zone properties; 595 were relevant to impact zone properties. Prior to analysis, all property values were deflated to base-year 1962 prices according to the residential structures price index (25, pp. 200-201).

Three multiple regressions (1 each for abutting, impact, and nonimpact zone) were performed by use of the price relatives constructed from various pairs of deflated property value sale-resale pairs. As has been mentioned, the regression model estimated the logarithms of the index numbers, and those results are given in Table 2. Also given in Table 2 are the estimated index numbers for each year from 1962 to 1972. For each category of property, the index number for the year 1962 was normalized to 1.000 for the sake of convenient comparison of other yearly index numbers to base year 1962.

Additional data that pertain to the regression results are tabulated as follows:

<u>Statistic</u>	<u>Abutting Zone</u>	<u>Impact Zone</u>	<u>Nonimpact Zone</u>
D-W	1.91	1.90	2.04
r^2	0.36	0.30	0.45
r_c^2	0.24	0.29	0.45

The computed values of the Durbin-Watson statistic D-W are well within the range of acceptability and indicate that the problem of correlated residuals, or autocorrelation, has not affected the results (as it often does when time-series investigations are made). The r^2 and r_c^2 corrected values indicate that the independent variables have explained only a moderate percentage of variation in the dependent variables. This, however, is quite acceptable considering that data inputs had already been deflated for general price rises, which naturally tends to explain a great deal of variation. Index numbers in each category generally rise from 1962 to 1972 and show the most marked increases in the later years. Figure 3 helps to show this observation.

STATISTICAL DIFFERENCES AMONG PRICE INDEXES

This section examines the hypothesis that transaction values of North Springfield properties close to I-495 were less than they would have been in the absence of the highway. For any given year, then, such a claim is valid if any of the following conditions exist:

1. Index for impact zone < index for nonimpact zone,
2. Index for abutting zone < index for impact zone, and
3. Index for abutting zone < index for control zone.

Because the multiple regression technique resulted in estimates of the true index numbers, the differences between such estimates were statistically evaluated to determine if any were significantly different from 0. Thus, for conditions 1, 2, and 3, the associated null hypotheses tested were that the differences between the respective index numbers were equal to 0. A 1-tailed Student's t-test was applied to each of the 3 null hypotheses, and this procedure was conducted for each of the 11 years. In only 4 statistical comparisons was it concluded that the null hypothesis should be rejected. Table 3 gives the pairs of significantly different index numbers. In the first line of Table 3, the 0.056 difference seen in 1970 between indexes computed for abutting and nonimpact zone properties was large enough to reject the notion that it occurred by chance. Expressing this difference in terms of 1970 dollars, an average abutting property is seen to have sold for \$1,650 less than a comparable nonimpact zone property. In both 1971 and 1972, significant differences were found between indexes computed for impact and nonimpact zone properties, and the index for abutting properties was significantly less than that for nonimpact zone properties in 1972.

It should be noted from Figure 3 that, in some years, computed index numbers were slightly higher for abutting or impact zone properties or both than for nonimpact zone properties. As a precautionary measure, such unexpected differences were tested for statistical significance. In all cases, the differences were found to be nonsignificant at the 10 percent level.

INTERPRETATION OF RESULTS

Two primary conclusions can be drawn from the research results:

1. North Springfield residential properties located in proximity to I-495 show a tendency to increase in value at a rate significantly less than that for properties more distant from the highway, and

Table 2. Property value price indexes and their logarithms.

Year	Abutting Zone		Impact Zone		Nonimpact Zone	
	Log of Index	Index	Log of Index	Index	Log of Index	Index
1962	0	1.000	0	1.000	0	1.000
1963	0.00096	1.002	0.00451	1.010	0.01101	1.026
1964	0.01222	1.028	0.01389	1.032	0.00747	1.017
1965	0.01781	1.042	0.02717	1.064	0.02760	1.065
1966	0.03831	1.092	0.03406	1.081	0.03666	1.088
1967	0.03395	1.081	0.03273	1.078	0.03259	1.077
1968	0.05308	1.130	0.04325	1.105	0.04626	1.113
1969	0.06968	1.174	0.05618	1.139	0.05923	1.147
1970	0.06874	1.171	0.08354	1.212	0.08906	1.227
1971	0.09513	1.245	0.09074	1.232	0.10213	1.265
1972	0.10059	1.261	0.10043	1.260	0.11730	1.310

Figure 3. Property value price indexes.

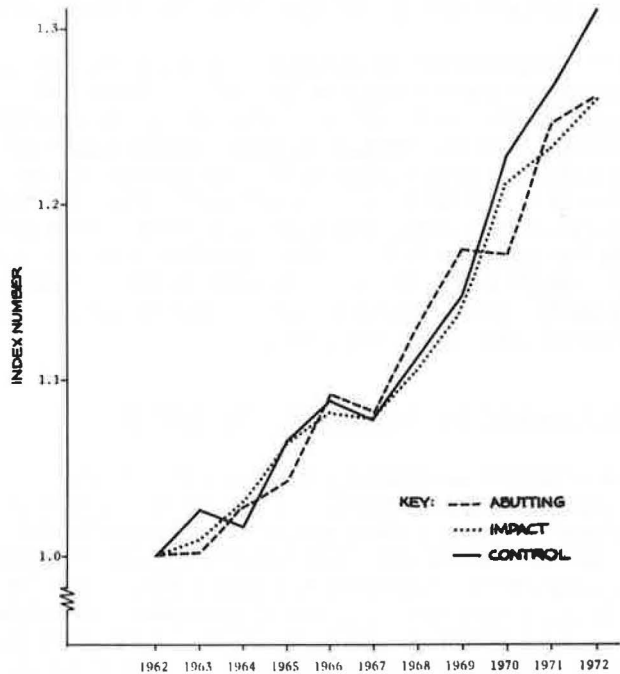


Table 3. Summary of significantly different index numbers.

Year	Index Numbers			Difference in Indexes	Dollar Differences*
	Abutting Zone	Impact Zone	Nonimpact Zone		
1970	1.171		1.227	-0.056	-1,650
1971		1.232	1.265	-0.033	-1,026
1972	1.261		1.310	-0.051	-1,652
1972		1.260	1.310	-0.050	-1,619

Note: All differences shown were significant at the 10 percent level when a 1-tailed Student t-test was applied to the data.

*Computed by multiplying the difference in indexes by the average value of all property sales occurring in the base year, 1962. The resulting product was then adjusted by price deflator to accurately reflect differences in terms of dollars in the relevant years.

2. The most recent year for which this phenomenon may be statistically validated is 1970.

It is incorrect to state that the highway had no adverse effects on property values before 1970. A more accurate observation to be made is that the time series of property value index numbers did not verify the existence of such effects. A probable explanation is that adverse highway effects such as noise and air pollutants were of lesser magnitudes in previous years. Substantially lower traffic volumes in earlier years tend to support this idea. Also residents might not have been so concerned about or aware of highway-related environmental effects in years before 1970. Recent emphasis on the environment has created a preference among potential homeowners for residences not located in an adversely affected area. The Clean Air Amendments of 1970 have specified the levels of motor vehicle emissions that are acceptable and defined the limits within which ambient air quality should fall.

COMPARISON OF FINDINGS WITH PREVIOUS RESULTS

As reported earlier in this paper, other researchers performed a cross-sectional analysis of North Springfield property sales values for 1970. Their finding that abutting properties sold for an average of \$1,518 less than comparable properties farther removed from the highway is substantially supported by the \$1,650 difference found by the technique used in this study. An interesting speculation can be made on the basis of the fact that the time-series analysis indicated significant differences only for years beginning with 1970. If the cross-sectional study had been conducted on property sales data for any year before 1970, variables measuring adverse highway impacts quite possibly might not have been significant in the explanation of residential property values. Similarly, such variables would be significant in cross-sectional studies of property sales data for more recent years.

RELEVANCE OF RESEARCH REPORTED

The research methodology employed in this study should serve as a substantial addition to the approaches currently employed by transportation planners to make equitable decisions concerning the construction or improvement of a limited-access highway. Although the results are not necessarily generally applicable in an operational sense to the case of any residential neighborhood that may be in the vicinity of a limited-access highway, a conceptionally sound procedure was employed, and it may be used to measure the adverse effects of particular highways on residential property values in other areas. Future research should be directed toward examining methodologies that may provide results that are more applicable to a wide variety of communities and highway-community relationships.

It has been reported in the literature that there is a component of property value in given areas that results from the perceptions of current and future residents of an increase in accessibility provided by a highway. Property value increases due to accessibility may be quite considerable in view of the impact on the community as a whole. For example, other researchers (8, 9, 10) showed for the case of North Springfield that accessibility benefits greatly outweighed, in dollar terms, the negative effects on values of some properties. In that study area, the benefit conferred on each property from increased accessibility primarily as a result of I-495 was found to be about \$2,950; the reduction in the average value of abutting properties due to adverse highway environmental effects was found to be only \$1,518. Future studies should attempt to provide methodologies capable of precisely quantifying this variable and its effect on properties in various land uses.

In the future, greater emphasis should be placed on ensuring that property owners are not subjected to adverse highway effects. The following implications from the study may be examined. Noise abatement and control of vehicular emissions should continue,

thus attacking the problem at the sources of the environmental disturbances—vehicle-roadway interfaces and the internal combustion engine. Modification of highway design as well as stricter land use controls on tracts near highways may also prove valuable. The benefit derived from such measures would be the reduction in social costs from the adverse effects of the highway.

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