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The Impact of Transit Corridors on Residential Property Values

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Abstract

Most of the literature on transit corridors, such as superhighways and tunnels, focuses on the positive externality of transit access (e.g., interstate access, transit station) and fails to isolate the negative externality of the corridor itself. This empirical study examines two situations: one with both access benefits and negatives, and another without the access benefit. The findings reveal that proximity to the transit corridor alone without direct access conveys a negative impact on nearby housing values.

Researchers have long been interested in the question of whether or not a relationship between transportation systems and housing prices and rents exists. In 1846, acting as what may have been the first transportation planning consultant, an unnamed "gentleman" conducted a door-to-door survey to determine the impact that the London's rail lines had on rents in the poor working districts of the city. This study, undertaken at the request of London's *Royal Commission on Metropolis Railway Termini*, determined that weekly and monthly rents in these districts rose from 10% to 25% as result of their proximity to public transportation stations.

Though the methodology involved has changed significantly—from the original "traveling salesman" approach, to matched pairs comparison in the 1950s, to the use of econometric modeling today—the purpose of this research remains the same. Specifically, researchers are interested in how transportation systems impact housing prices. The types of transportation infrastructure of interest have evolved along with the urban environment, from commuter rail to multi-land limited access highways, and airports and, most recently, returning full circle to commuter and/or light rail systems.

Transportation systems affect property values in two key ways: positively, via the increased accessibility that they provide, and negatively, due to the negative externalities associated with being close to them. Generally, the increase accessibility is a public benefit, while a relatively few property owners bear the negative impacts. As a result, decisions regarding where to locate new systems and/or expansions to existing systems are controversial, particularly because of the difficulty involved in balancing the public benefits with the externality costs borne by those few property owners. While transportation systems clearly enhance neighborhood accessibility, they also negatively affect real estate values by producing noise, pollution, crime, and, in the case of properties located directly in their path, via stigma. These factors, both positive and negative, capitalize into the value of homes in the same matter that extra bathrooms, pools, and/or desirable locations do.

Unfortunately, many prior studies examine the overall impact on affected properties, combining the positive public good with the negative externality. The purpose of this paper is to isolate and empirically investigate the negative impact of a transit corridor separately from the public benefits.[1]

The following section reviews the recent literature, focusing on hedonic empirical studies conducted since the 1970s and placing the findings in the context of real estate theory. Next, there is a discussion of an empirical model, which is tested using two different data sets. The first data set consists of sales of homes in a suburban interstate highway corridor, which have varying degrees of both proximity benefits and negative impacts. Findings from this model aid in constructing a second model that analyzes home sales over and near a tunnel easement, which have negative impacts but do not enjoy proximity benefits. This second data set allows also for development of a distance function, in much the same way Colwell (1990) did for power lines. The paper closes with concluding remarks and recommendations for further research.

Literature Review

The real estate value impact of proximity to externalities in general has been explored from numerous perspectives in the literature, and was well summarized in Lentz and Wang (1998). Specific to transportation externalities, studies from the United States and Canada have generally shown a positive average relationship between proximity to transit stations and neighboring housing values. For example:

- United States House of Representatives (1981) reveals a $12,300 premium paid for town homes located within 1,000 feet of a Washington D.C. Metro station;
- Bajic (1983) shows an increase of $2,237 for homes in Toronto's Spadina neighborhood, which were near subway stations;
- Voith (1993) reports an increase of 6.4% for homes near Philadelphia's train stations;
- Armstrong (1994) finds a housing price premium of 6.7% for suburban Boston communities with commuter rail stations;
- Landis et. al. (1995) find that home prices decline $1–$2 per meter distance from a Bay Area Rapid Transit (BART) station in California;

- Benjamin and Sirmans (1996) reports a decrease of 2.4% to 2.6% in housing price for every tenth of a mile from a Washington D.C. Metro station;
- Workman and Brod (1997) examines individual San Francisco neighborhoods and finds a decline of $2,300 in home prices for every 100 feet from a BART station in one neighborhood and $1,578 for every 100 feet in another;
- Sedway Group (1999) reports a decline in housing price of $74 per foot from a BART station within the first quarter of a mile and $30 per foot for those greater than a quarter of a mile away;
- Baum-Snow and Kahn (2001), a multi-city study analysis, finds that moving from three miles to one mile away from a transit station creates a rent increase of $19 per month and a housing premium of $4,972; and
- Garrett (2004), a study on the Metrolink in St. Louis, shows an increases of $140 in home price per 10 feet closer to a station.

This collection of research exposes the economic benefits of accessibility, expressed, in each case, as proximity to a transit station. The basis for this relationship was first developed by von Thunen in 1826. Within that framework, increases in rents and housing prices due to accessibility—whether from a new rail station, bus stop, or freeway onramp—are caused by subsequent decreases in commuting costs, measured in time. Through what is known as the *compensation principle*, reduced transportation costs allow households to spend more on housing and, in turn, bid up the rents or prices of homes located in areas with low commuting costs; this is precisely what creates the land value/density gradient. The studies listed above fall in line perfectly with rent theory regarding the relationship between accessibility and home prices and rents. A practical application of this is the Fannie Mae-sponsored *location efficient mortgage* program, which allows households located in areas served by mass transit to borrow more money, with the understanding that less of their income will be spent on transport costs, such as automobile payments.[2]

In the context of transportation planning, it is important to bear in mind that with accessibility comes the negative externalities of pollution, crime, and noise, plus the stigma that arises as homebuyers seek to avoid the risk associated with being proximate to the line or route.[3] Thus, while these studies reveal positive average benefits, the findings generally do not try to separate the benefits from the costs. The real estate literature also explores situations where an otherwise benign or even positive externality can have negative impacts on proximate property values. For example, Wang, Grissom, Webb, and Spellman (1991) show that the development of single-family rental housing can have a negative impact on nearby owner-occupied residences. Many studies focused on transportation reveal situations where the costs exceed the public benefits of transportation access or where costs and benefits are in balance such that there is no average impact.

For example, a study by Forrest, Glen, and Ward (1996) in Manchester, England, shows significant decreases in housing values for homes located within two miles of Metrolink (2.1%–8.1%) and non-Metrolink (4.4%–4.5%) stations. Likewise, Landis, Guhathukurta, and Zhang (1994) find that proximity to a light rail station in San Jose, California decreases home prices on the order of $31,000. Gatzlaff and Smith (1993) report that, overall, proximity to Miami's Metrorail station has no statistically significant impact on house prices. Last, Spengler's 1930 study shows that proximity to transit stations does increase house values, but at the expense of those homes farther away. This *zero-sum* theory has been reinforced by subsequent studies from Mohring (1961), Boyce et al. (1972), and Allen and Mudge (1974).

Some recent research has been much more specific in identifying the various ways in which transit systems influence the value of housing. For instance, some of these studies have accounted for the income of the neighborhood, distance from the central business district, or the existence of a parking lot on site. In their study of the Miami Metrorail system, Gatzlaff and Smith (1993) find that higher income neighborhoods experienced benefits, while lower income areas experienced no impact. Conversely, Nelson (1992) and Bowes and Ihlanfeldt (2001) find that high (low) income neighborhoods are negatively (positively) affected by MARTA stations in Atlanta. The latter study reports that increases in property values were greater farther from the central business district, an effect attributed to the line-haul costs associated with transit trips. It also finds that the existence of a parking lot, which may promote increased crime rates, significantly decreases values within the immediate (quarter mile) vicinity of stations. The 1997 Workman and Brod study shows the same localized effect, with decreases in value observed in the first two to three blocks surrounding a station giving way to premiums by the fifth or sixth block.

Both the positive and negative impacts of transit systems can vary through time. McDonald and Osuji (1995) report that, in the three years before its construction, Chicago's Midway Line increased values of homes within a half mile of proposed stations by 17%. A follow-up study by McMillen and McDonald (2004) shows that, from announcement in 1983 to 1987, the proposed Midway Line increased home values within a half mile by 4.2%, from 1991 to construction in 1996, it increased home values by 19.4%, but, then, post-construction, from 1997 to1999, home values fell 9.8% within that same half mile distance. The post-construction drop was attributed to both the realization of negative externalities and the potential deflation of what was believed to be an artificially strong market in those areas surrounding the transit stations. Knaap, Ding, and Hopkins (2001) show similar increases of 31% (half-mile radius) and 10% (half- to one-mile radius) in an analysis of vacant parcels surrounding the proposed Westside expansion of the MAX light rail system in Portland, Oregon.

The important finding from this literature is that *accessibility* is what creates value and, moreover, that this accessibility is gained by proximity to stations, stops, and onramps and not to the line or the highway in general. For this reason, proximity to a rail line or freeway simultaneously generates negative externalities in the form of pollution, noise, and aesthetic unpleasantness while failing to provide the benefits associated with accessibility. Knaap, Ding, and Pant (1996) show that, while properties within a half mile of Portland's MAX stations command a premium, those within half mile of the line, but not near a station, decreased in value. Landis et. al. (1995) report the decrease in value associated with being located within 300 meters of a CalTrain line at $51,000. With respect to freeways, a study by Cervero (2003) in San Diego County shows multifamily residential parcels located a mile or more away from the freeway command a $67,000 premium; however, at the same time, parcels located more than one mile from an onramp experience a $43,000 decrease in value. In short, proximity to access points, including both rail stations and highway onramps, has a positive influence on value, while proximity to the line or route itself has a negative influence.

As with most economic research, the results of the studies reviewed here vary widely based on location, socio-economic factors, and the individual transit systems. Many of the studies offer interesting observations or caveats pertaining to the nature of their findings. For example, Damm et al. (1980) note that, in studying the effects of proposed transit sites, the results may be biased since planners attempt to locate these stations in areas that would be most conducive to high ridership or other measures of successful infrastructure planning. Cervero (2003) states that the negative externalities of transit sites may go relatively unnoticed and, therefore, are not capitalized into home prices in dense mixed use areas that are already impacted by noise, pollution, and/or crime. This study also notes the inherent difficulty of utilizing rental data because contract rents do not generally account for landlord concessions. Also, as McMillen and McDonald (2004) explain, only home prices, not rental rates, are affected prior to construction due to the fact that the speculative benefits of future accessibility do little for the renter. Knaap, Ding, and Hopkins (2001) note that, after the announcement of a transit line and, subsequently, throughout the life of the system, residential sorting occurs; households that prefer transit will locate in homes that are proximate to stations, while others will move away. See Boarnet and Crane (2001) for a careful analysis of the kind of *chicken-or-egg* question that arises around the relationship between people's residential and transportation choices.

On the surface, research on the relationship between transportation infrastructure and property values appears to support the conclusion that proximity has a positive influence. However, when the benefits to the public at large are separated from the costs born by individual property owners, a different picture emerges: Transit systems are revealed to simultaneously raise and lower property values, depending on distance to stations and onramps, which grant accessibility, and distance to the line or route itself, which the market is adverse to. For this reason, the following empirical analysis, which estimates the impact that the tunnel easements will have on the subject properties, takes careful steps to disentangle the two effects.

Model Development and Testing

As discussed in the preceding section, any evaluation of how a transit system affects property values must be designed to avoid confusing the benefits to the public at large with the costs borne by individual property owners. Toward this end, two separate analyses are performed. The first model the ("Interstate 90 model") uses a data set of residential sales over a four-year period along a stretch of Interstate 90 between Mileposts 0 (the intersection with Interstate 5 near downtown Seattle) and Milepost 15 (generally, the eastern edge of the Seattle suburbs). The sales in this data set should be impacted by both the public good value of proximity to access versus the negative impacts of proximity to the corridor.

The second model ("Mt. Baker Tunnel") utilizes fifteen years of residential sales data from the Mt. Baker neighborhood of Seattle, which overlies a portion of I-90, roughly from Milepost 2 to Milepost 3, in which the highway is entirely within tunnels. Specifically, this neighborhood is bisected from east-to-west by four tunnels, about a half-mile in length. Homes in this neighborhood do not enjoy the public good of access to the tunnel, but would be hypothesized to evidence negative impacts of proximity. By using a data set without the proximity benefit, this second analysis can estimate a distance component to the negative impact.

Homes in both data sets enjoy value impacts from water proximity and views, and Bond, Seiler, and Seiler (2002) show this to be the predominant determinant of value after dwelling and lot size. Also, view is shown to be important in Des Rosiers (2002), albeit as a negative component when viewing a negative externality.

Interstate 90 Model

In the first step, the positive and negative effects of Interstate 90 are demonstrated by estimating a hedonic price model involving 1,321 sales of single-family homes that took place between 2002 and early 2005 and are located in a one-mile wide band centered on the corridor.[4]

The Interstate 90 corridor has been established for many years, and while some new construction continues, the neighborhoods surrounding the corridor are nearly fully developed. Home prices are generally near the top of the Seattle suburban market, and the neighborhood is thought to enjoy positive amenities.[5] Milepost 0 for I-90 is in its intersection with Interstate 5 near downtown Seattle. At present, mass transit in the Seattle market is limited to buses. As such, the I-90 corridor provides the only transportation alternative from this up-scale suburb to the central business district. Thus, access to the interstate on-ramps would constitute a substantial public benefit for homes in the study area.

Conversely, the interstate corridor passes within sight of the southern edge of Lake Sammamish and crosses Lake Washington via bridges. It bisects east-to-west the upscale suburban cities of Issaquah and Bellevue (Bellevue is also bisected north-to-south by I-405) and transverses the City of Mercer Island. I-90 is busy nearly twenty-four hours per day, and is the site of considerable ongoing maintenance and construction. As such, the annoyance of proximity to the interstate corridor, particularly for those homes in a direct line-of-sight, should be real and measurable.

To measure this, the transaction data is analyzed via the following hedonic price model:

$$\ln(price_i) = \delta_0 + \delta_1 \ln(x_i) + \delta_2 \ln(z_i) + \delta_3 time_i + \varepsilon_i. \quad (1)$$

In this equation, the dependent variable, $\ln(price_i)$, is the natural logarithm of the sales price of house i; $\boldsymbol{x}$ represents a vector of unit characteristics, including the size in square feet of the lot, the size in square feet of the home, and the age in years of the home at the time of the sale; z represents a vector of locational characteristics, including the median household income in the home's census tract, the natural logarithm of the home's distance in feet from the nearest lake (Lake Sammamish or Lake Washington), the natural logarithm of the home's distance in feet from Interstate 90, and the natural logarithm of the home's distance in feet from the nearest Interstate 90 onramp; δ_0, δ_1, δ_2, and δ_3 represent estimable parameters; and ε_i represents the stochastic error term. The equation is a *linear in parameters* function that meets all of the assumptions required for ordinary least squares (OLS) estimation, including that $\varepsilon \sim N(0, \sigma^2)$.

The OLS estimation results are shown in Exhibit 1. Assuming two-tailed hypothesis tests, all variables are significant at well over a 99% confidence interval and the adjusted R^2 is 0.74. The results show that housing prices are: positively influenced by lot and building size; negatively influenced by age; positively influenced by the median household income of the surrounding neighborhood; negatively influenced by distance from Lake Washington or Lake Sammamish; positively influenced by distance from Interstate 90; negatively influenced by distance from Interstate 90 onramps; and positively influenced by time, which reflects market-wide appreciation. While each of these relationships is consistent with expectations, the distance variables require some additional explanation. Specifically, the negative signs on the Lake Washington/Sammamish and Interstate 90 onramp variables indicate that the farther away from these features a home is located, the lower the price. That is, other things being equal, homes located on the lakefront sell for more than homes located at some distance away; similarly, the closer a home is to an Interstate 90 onramp, the greater the price. Conversely, the positive sign on the Interstate 90 variable indicates that, other things being equal, homes increase in value with distance from the freeway. In short, the results of the model support the hypothesis that transportation infrastructure (Interstate 90, in this case) simultaneously raises property values by granting accessibility but lowers them via negative externalities, such as air and noise pollution—and the stigma associated with being close to them.

Exhibit 1 | OLS Estimates of I-90 Corridor Hedonic Model

	Mean Value	δ	t
Constant		14.14586	90.89
Lot Square Feet	10,640	0.00001	9.65
Building Square Feet	2,365	0.00029	31.65
Age (years)	40	−0.00124	−3.64
Locational Characteristics			
Median household income ($)	68,299	0.00000	2.44
ln Distance from Lake Sammamish/Washington (feet)	3,357	−0.20317	−23.25
ln Distance from I-90 (feet)	1,433	0.06020	5.56
ln Distance from I-90 Onramp (feet)	2,887	−0.12673	−7.69
Time[a]		0.00772	10.30
Adj. R^2			0.74

Notes: $N = 1{,}321$.
[a]Months since closing, beginning January, 2002.

Mt. Baker Tunnel Corridor Model

Analysis of the previous data set allowed for a differentiation between positive impacts of public benefits and negative value impacts of corridor proximity. However, does proximity to the corridor alone cause the negative value impacts? This question is important for determination of the stigma impacts of tunnel easements absent any specific physical disutility as a result of the tunnel. In other words, if the transit corridor is buried in a tunnel, does it still impact property values?

In order to do this, a hedonic price model is estimated based on 668 sales of single-family homes between 1990 and early 2005 in the Mt. Baker neighborhood of Seattle. While this neighborhood is geographically a subset of the I-90 corridor area, the neighborhood is unique in that the homes there do not have easy access to I-90 via on-ramps and as such do not enjoy the positive public benefits. Also, I-90 enters a tunnel at the west bank of Lake Washington (the eastern side of Mt. Baker) and continues through that tunnel for slightly over a mile until exiting on the west side of Mt. Baker near its intersection with I-5. As such, the impact of the transit corridor is purely the stigma associated with the tunnel easement.[6] Also, to obtain a robust sample, the time period for this data set was extended back in time to 1990.

Each of the included properties is located within a half mile of the Interstate 90 tunnel;[7] the closest are located directly on top of it.[8] The influence of the tunnel on the surrounding property market is estimated via the following hedonic price model:[9]

$$\ln(price_i) = \gamma_0 + \gamma_1\ln(w_i) + \gamma_2\ln(x_i) + \gamma_3\ln(z_i) + \gamma_4 time_i + \varepsilon_i. \quad (2)$$

Here, the dependent variable, $\ln(price_i)$, is the natural logarithm of the sales price of house i; $\boldsymbol{w}$ represents a vector of unit characteristics; $\boldsymbol{x}$ represents a vector of neighborhood characteristics; z represents a vector of distances; *time* represents a continuous (monthly) time variable, γ_0, γ_1, γ_2, γ_3, and γ_4 represent estimable parameters or vectors thereof; and ε_i represents the stochastic error term. The individual variables embedded in each of the vectors are as follows: The vector $\boldsymbol{w}$ is composed of the size in square feet of the house's lot, the size in square feet of the house, and the age in years of the house at the time of the sale, all in quadratic form (meaning that the equation contains the variables and their square), plus dummy variables indicating if the home is of good, very good, better, excellent, or luxury grade, dummy variables indicating if the home is in good or very good condition, and a dummy variable indicating if the home has a view; the vector $\boldsymbol{x}$ is composed of the median household income in the house's census tract and, as a measure of accessibility, the natural logarithm of the mean commute time in the house's census tract; and the vector z is composed of the natural logarithm of the house's distance in feet from Lake Washington; and the natural logarithm of the house's distance in feet from the Interstate 90 tunnel.

Note that, in this model, mean commute time is used instead of the distance to the nearest Interstate 90 onramp. Because of the previously discussed lack of direct access to I-90, there is not enough variation in the dataset with respect to the latter to produce meaningful results.[10] Plus, because the data covers such a small geographic area, including both the distance to the highway and the distance to the onramp in the equation creates *multicollinearity*, a fundamental violation of the linear regression model. Since the distance to the Interstate 90 tunnel is the variable of interest, it is retained and distance to the onramp is replaced with mean commute time, which serves as an instrumental variable, or proxy, that captures the same effect.[11] With this minor adjustment, the equation becomes a *linear in parameters* function that meets all of the assumptions required for OLS estimation, including that $\varepsilon \sim N(0, \sigma^2)$.

The OLS estimation results, including individual parameter estimates (the γs) and t-Statistics, are shown in Exhibit 2. Assuming two-tailed hypothesis tests, all variables are significant at a 99% confidence interval and the adjusted R^2 shows that the model explains over 75% of the variation in the dependent variable. To be clear, the interpretation of each variable is made *holding all else constant*; that is, the coefficients are partial derivatives between the dependent and independent

Exhibit 2 | OLS Estimates of the I-90 Tunnel Hedonic Model

	Mean Values	γ	T
Lot Square Feet	4,738	0.00003	2.71
Lot Square Feet^2	29,490,537	0.00000	−2.46
Building Square Feet	2,249	0.00031	4.67
Building Square Feet^2	5,988,960	−0.00000	−2.02
Age (years)	69	−0.00148	−3.18
Age^2 (years^2)	28,494	0.00000	3.96
Building Grade			
Good	0.265	0.22977	6.47
Very Good	0.031	0.30144	3.37
Better	0.091	0.33847	6.41
Excellent	0.009	0.46050	2.84
Luxury	0.006	1.12472	5.13
Building Condition			
Good	0.326	0.10647	3.44
Very good	0.082	0.19315	3.92
View	0.442	0.17439	5.67
Neighborhood Characteristics			
Median household income ($)	48,863	0.00002	4.67
ln Mean commute time	3.140	−1.24036	−2.81
Location			
ln Distance from Lake Washington	7.220	−0.18498	−11.96
ln Distance from I-90 Tunnel	7.108	0.03941	2.05
Time[a]		0.00605	12.91
Constant		14.73158	11.68
Adjusted R^2			0.76

Notes: $N = 668$.
[a]Months since closing, beginning January, 2002.

variables. So, each characteristic carries a *marginal implicit price* that factors into the trade-offs people make when they bid on housing. Most importantly for purposes of this study, note that the accessibility and distance variables, the natural logarithms of mean commute time and distance to the Interstate 90 tunnel, carry their expected negative and positive signs: longer commute times decrease housing prices and distance from the Interstate 90 tunnel increases housing prices. Both of these findings are consistent with the conclusions drawn from the literature review in the preceding section and are also consistent with the analysis of sales along a wider segment of Interstate 90.

The parameters (γs) shown in Exhibit 3 are used to estimate the premium or discount paid for various amenity-related variables contained in the hedonic model by applying them to a baseline home, at assumed values of the regressors. As shown in Exhibit 3, for this purpose, the baseline house is assumed to: have a lot size of 5,000 square feet; contain 2,000 square feet of living space; be 75 years old, of good grade, and good condition; have a view; be located in a census tract with a median household income of $45,000 and a mean commute time of 22 minutes; be located 500 feet away from Lake Washington and 200 feet away from the Interstate 90 tunnel; and to have sold in early 2005. The product of these values and the estimated parameters is shown in the third column of Exhibit 3; their sum, plus the constant, is the natural logarithm of the estimated sales price of a home with the specified characteristics. Exponentiation of this value, 14.73, produces an estimated sales price of $636,913 for the baseline home.

Next, the premiums paid for various building grades and conditions, having a view, and location with respect to Lake Washington and the Interstate 90 tunnel are estimated by allowing each to vary in isolation and recalculating the baseline value produced by the model. The results are as follows: relative to a good building grade, very good carries a premium of $48,088, an increase in price of 7.43%; better carries a premium of $74,317, an increase in price of 11.48%; excellent carries a premium of $167,958, an increase in price of 25.95%; and luxury carries a premium of $936,593, an increase in price of 144.72%; relative to being in good condition, very good carries a premium of $58,605, an increase in price of 9.05%; relative to having a view, not having a view caries a discount of $103,565, a decrease in price of 16.26%; relative to being 500 feet away from Lake Washington, a home located on the shoreline caries a premium of $1,395,881, an increase of 215.69%; and, finally, relative to being 300 feet away from the Interstate 90 tunnel, a home located right on top of it carries a discount of $130,290, a decrease of 20.13%. Since each of these calculations is made holding all else constant, the percentages (but not the actual dollar figures) associated with each amenity or disamenity are generalizable to other situations. Further, because this model is fully specified, the parameter estimates and, in turn, the implicit prices they produce, can be interpreted with confidence.[12]

When modeling spatial phenomena—such as variation of housing prices with respect to distance from an amenity or disamenity—it is of no small consequence to ensure that the error term does not exhibit a systematic spatial pattern. Consistent over or underestimation of prices near to the Interstate 90 tunnel or in a given section of the surrounding Mt. Baker neighborhood, for example, would be a clear sign of omitted variable bias.

To test for this, the residuals, ε_i, produced by the hedonic model were mapped to provide a visual test of randomness. It was determined that the residuals followed a random spatial pattern, providing further evidence that the model is properly specified and, accordingly, that the parameter estimates may be interpreted with a high level of confidence. In short, this straightforward test lends strong support

Exhibit 3 | Estimated Value of Amenity-Related Variables

	γ	Typical x	γ*x
Lot Square Feet	0.00003	5,000	0.149
Lot Square Feet^2	−0.00000	25,000,000	−0.029
Building Square Feet	0.00031	2,000	0.611
Building Square Feet^2	−0.00000	4,000,000	−0.102
Age	−0.00148	75	−0.111
Age^2	0.00000	5,625	0.005
Building Grade			
Good	0.22977	1	0.230
Very good	0.30144	0	0.000
Better	0.33847	0	0.000
Excellent	0.46050	0	0.000
Luxury	1.12472	0	0.000
Building Condition			
Good	0.10647	1	0.106
Very good	0.19316	0	0.000
View	0.17439	1	0.174
Neighborhood Characteristics			
Median household income	0.00002	45,000	0.693
ln Mean commute time	−1.24036	22	−3.834
Location			
ln Distance from Lake Washington	−0.18498	500	−1.150
ln Distance from I-90 Tunnel	0.03941	300	0.225
Time	0.00605	278	1.682
Constant	14.73158	1	14.732
Sum of γ*x			13.364
Estimated Value @ typical x ($)			$636,913
Building Grade—Relative to Good		Value	%
Very good		$48,088	7.43%
Better		$74,317	11.48%
Excellent		$167,958	25.95%
Luxury		$936,593	144.72%
Building Condition—Relative to Good			
Very good		$58,605	9.06%
No View—Relative to View		−$103,565	−16.26%
Location—Relative to Baseline Distance			
ln Distance from Lake Washington		$1,395,881	215.69%
ln Distance from I-90 Tunnel		−$130,290	−20.13%

to the modeling results. A more thorough discussion of the use and evaluation of such a parsimonious spatial model is in Besner (2002).

Returning to the interpretation of amenity-related estimates, the distance functions associated with Lake Washington and the Interstate 90 tunnel require further explanation. Specifically, these functions form exponential curves that asymptotically approach zero; that is, as distance increases, the influence of the lake and underground tunnel decreases to a point where it is no longer relevant. The baseline values were therefore selected to reflect the points at which the functions begin to level off and no longer have a meaningful influence on property values—500 feet in the case of the lake and 300 feet in the case of the tunnel. The localized influence of the Interstate 90 tunnel is shown graphically in Exhibit 4, which illustrates how the estimated sales price of housing varies with distance while holding all else constant. The curve flattens at a distance of 300 feet, the point of the red diamond, where the tunnel no longer has a meaningful effect on the market; because the function is continuous, it goes on rising, but so slowly that the growth that occurs between, say, 300 and 500 feet is essentially zero. The distance curve associated with Lake Washington works the same way, except that property values fall as distance increases to 500 feet. Both of these distances are

Exhibit 4 | Price Effect of the Interstate 90 Tunnel

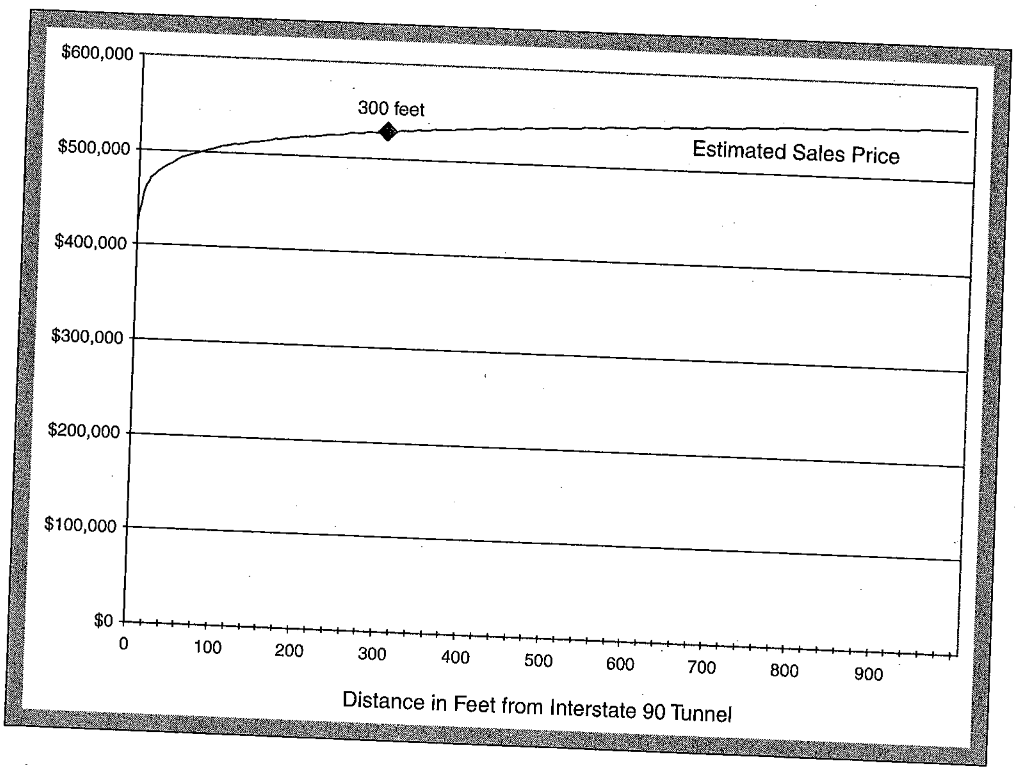
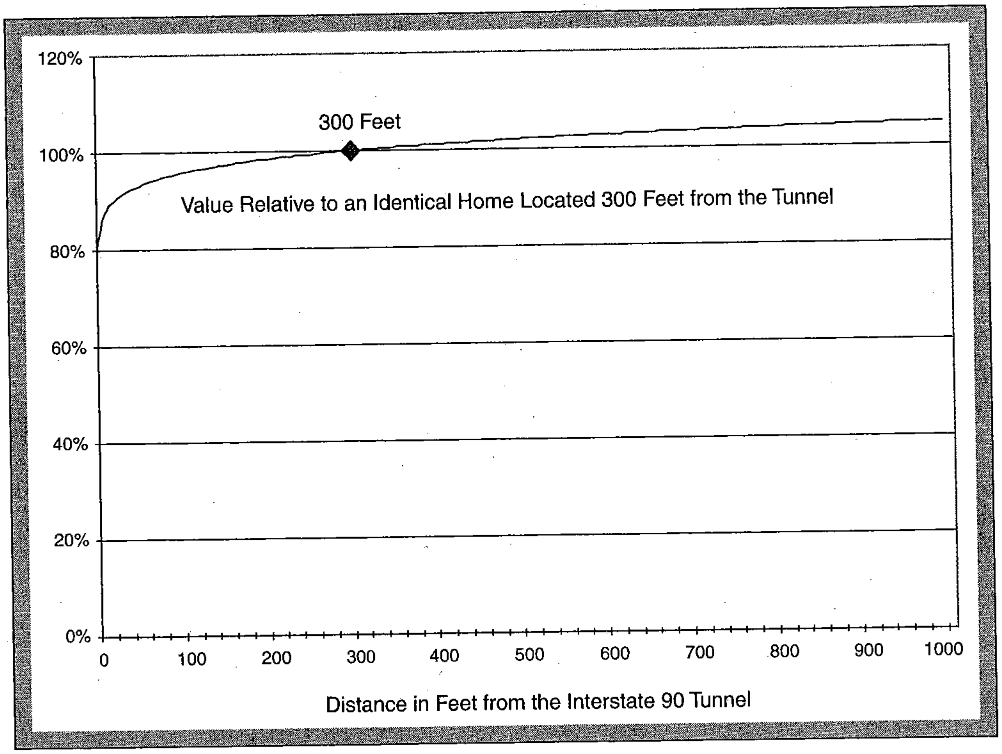


Exhibit 5 | Relative Price Effects of the Interstate 90 Tunnel



logical. In the case of the Interstate 90 tunnel, an influence is felt for a block, or, put differently, the distance between it and Irving Street, just to the north.

The diminution in value associated with the Interstate 90 tunnel—which is attributed to the stigma associated with being proximate to it, because it produces no noticeable air or noise pollution, vibrations, or other negative externalities—is shown in Exhibit 5. Compared to a home located 300 feet away, where the tunnel no longer has a meaningful influence, a home that is identical in all other respects is estimated to be worth 20% less. Just like the 20% shown in Exhibit 3, the curve shown in the figure was calculated by dividing the estimated sales price of an identical home located at different distances from the Interstate 90 tunnel by the estimated sales price of a home located 300 feet away. Since price is a monetary expression of value, a 20% diminution is adopted as the estimated influence that the tunnel has on the value of single-family homes located directly on top of it.[13]

Summary and Recommendations for Further Research

This study develops two empirical models to separate the stigma impact of a transit corridor—and specifically a tunnel—from the amenity value associated with access to the transit corridor. Prior studies fail to account for the interaction of these two.

The study specifically finds that proximity stigma has a linear spatial component. Stigma associated with a tunnel appears to ameliorate at about 300 feet from the tunnel, and relative to this baseline, a residence immediately proximate to or over the tunnel will suffer a diminution in value of approximately 20%.

The study suggests several additional avenues of research. For one, the two transaction data sets are drawn from relatively up-scale neighborhoods, which enjoy high demand. Would these same findings emerge in neighborhoods of less demand, or would the stigma impacts be worse? Second, the interstate highway corridor in question is nearly the only route from these suburbs to the central business district. If alternate routes were available, or if non-bus mass transit was available, would the public benefits of interstate access be as robust?

Finally, one of the most important uses of this study is to measure the stigma impact on houses in transportation eminent domain actions. However, both data sets came from well-established neighborhoods and a transit corridor that has been in place for many decades. Would similar results emerge as a result of a changing neighborhood with a new transit corridor?

Endnotes

[1] A similar benefit-versus-detriment issue was raised in early studies of overhead power lines, as illustrated by Colwell (1990).

[2] See: http://www.locationefficiency.com/.

[3] One reviewer posed the simultaneity issue: do transit lines reduce home prices, or are transit lines purposely located in the midst of low-priced areas? While an intriguing question, the empirical portion of this study controls for this by analyzing home sales from two relatively homogenous neighborhoods: one bordering I-90 and one over and near a tunnel easement. Both transit corridors have been in place for many decades, and as a historical note, both locations were chosen as a result of topography and terrain rather than socio-economics.

[4] The most distant home in this data set is located 2,977 feet away from Interstate 90; the closest is located directly on to of it, above the Mt. Baker tunnel.

[5] Indeed, some of the most expensive homes in the United States are within the study area, including the home of Paul Allen, co-founder of Microsoft. The waterfront home of Bill and Melinda Gates in Medina is within sight of I-90, but outside of the study area.

[6] For simplicity, this is referred to as an easement. Technically, the Department of Transportation does not own an easement but owns, in fee, the subterranean property within the transit corridor. When the tunnel was built, in the mid-1900s, the government condemned both the surface and the subsurface rights needed for construction. When the tunnel was completed, the surface rights and limited subsurface rights immediately above the tunnel were re-conveyed to property owners who built homes in that neighborhood. The existing homes have been constructed since the mid-1900s.

[7] Specifically, the most distant property is located 2,989 feet away from the tunnel.

[8] No property actually registers a zero, because distance is calculated at a right angle from the center line of the Interstate 90 tunnel.

[9] The functional form of this model used here based in part on Brasington (2000) and Benson, Hansen, and Schwartz (2000).

[10] For all properties in the dataset, the closest onramp is the one located near the intersection of Interstate 90 and Rainier Avenue.

[11] For a discussion on the use of instrumental variables, see Kennedy (2003).

[12] Extensive sensitivity testing was undertaken to ensure that this model does not suffer from omitted variable bias and/or other econometric issues that would cause the results to be interpreted with reduced confidence.

[13] One reviewer noted that the exponential form used here forces a near-zero impact at a distance, and that a distance zone variable might be more enlightening. While the impact of distance observationally appears to become asymptotic (see Exhibit 5), further research with this alternative variable specification may illustrate other neighborhood characteristics interacting at a distance from the tunnel.

References

Allen, B. and R. Mudge. The Impact of Rapid Transit on Urban Development: The Case of the Philadelphia Lindenwold High Speed Line, Rand Corporation Paper P-5246, 1974.

Alonso, W. *Location and Land Use*. Cambridge, MA: Harvard University Press, 1964.

Armstrong, R. Impacts of Commuter Rail Service as Reflected in Single-Family Residential Property Values. *Transportation Research Record*, 1994, 1466, 88–97.

Bajic, V. The Effects of a New Subway Line on Housing Prices in Metropolitan Toronto. *Urban Studies*, 1983, 2, 147–58.

Baum-Snow, N. and M. Kahn. The Effects of Public Transit Projects to Expand Urban Rail Transit. *Journal of Public Economics*, 2001, 77, 241–63.

Benjamin, J. and G.S. Sirmans. Mass Transportation, Apartment Rent and Property Values. *Journal of Real Estate Research*, 1996, 12:1, 1–8.

Benson, E., J. Hansen, and A. Schwartz. Water Views and Residential Property Values. *The Appraisal Journal*, 2000, July, 260–71.

Besner, C. A Spatial Autoregressive Specification with a Comparable Sales Weighting Scheme. *Journal of Real Estate Research*, 2002, 24, 193–211.

Boarnet, M. and R. Crane. *Travel by Design: The Influence of Urban Form on Travel Behavior*. New York City, NY: Oxford University Press, 2001.

Bond, M.T., V. Seiler, and M. Seiler. Residential Real Estate Prices: A Room with a View. *Journal of Real Estate Research*, 2002, 23, 129–38.

Bowes, D. and K. Ihlanfeldt. Identifying the Impacts of Rail Transit Stations on Residential Property Values. *Journal of Urban Economics*, 2001, 50, 1–25.

Boyce, D. et. al. The Impact of Rapid Transit on Suburban Residential Property Values and Land Development: Analysis of the Philadelphia High Speed Line. Regional Sciences Department, Wharton School, 1972.

Brasington, D.M. Demand and Supply of Public School Quality in Metropolitan Areas: The Role of Private Schools. *Journal of Regional Science*, 40, 2000, 583–605.

Cervero, R. Effects of Light and Commuter Rail Transit on Land Prices: Experiences in San Diego County. Department of City and Regional Planning, University of California–Berkeley. Working Paper, 2003.

Colwell, P. Power Lines and Land Values. *Journal of Real Estate Research*, 1990, 5:1, 117–27.

Damm, D., et. al. Response of Urban Real Estate Values in Anticipation of the Washington Metro. *Journal of Transport Economics and Policy*, 1980, September, 315–36.

Des Rosiers, F. Power Lines, Visual Encumbrance, and House Values: A Microspatial Approach to Impact Measurement. *Journal of Real Estate Research*, 2002, 23, 275–301.

Forrest, D., J. Glen, and R. Ward. The Impact of a Light Rail System on the Structure of House Prices: A Hedonic Longitudinal Study. *Journal of Transport Economics and Policy*, 1996, 30:1, 15–29.

Garrett, T. Light Rail in America: Policy Issues and Prospects for Economic Development. Federal Reserve Bank of St. Louis, 2004.

Gatzlaff, D. and M. Smith. The Impact of the Miami Metrorail on the Value of Residences Near Station Locations. *Land Economics*, 1993, 69:1, 54–66.

Kennedy, P. *A Guide to Econometrics*. Cambridge, MA: The MIT Press, 2003.

Knaap, G., C. Ding, and L. Hopkins. Do Plans Matter? The Effects of Light Rail Plans on Land Values in Station Areas. *Journal of Planning Education and Research*, 2001, 21, 32–9.

Knaap, G., L. Hopkins, and A. Pant. Does Transportation Planning Matter? Explorations into the Effects of Planned Transportation Infrastructure on Real Estate Sales, Land Values, Building Permits, and Development Sequence. Lincoln Institute of Land Policy Research Paper, 1996.

Landis, J., R. Cervero, S. Guhathukurta, D. Loutzenheiser, and M. Zhang. Rail Transit Investments, Real Estate Values, and Land Use Change: A Comparative Analysis of Five California Rail Transit Systems. Monograph 48, Institute of Urban and Regional Studies, University of California–Berkeley, July 1995.

Landis, J., R.S. Guhathukurta, and M. Zhang. Working Paper 619, Berkeley Institute of Urban and Regional Development, University of California, 1994.

Lentz, G.H. and K. Wang. Residential Appraisal and the Lending Process: A Survey of the Issues. *Journal of Real Estate Research*, 1998, 15, 11–39.

Metrorail Impacts on Washington Area Land Values, Staff for the Subcommittee on the City. Committee on Banking, Finance, and Urban Affairs, U.S. House of Representatives, 1991.

McDonald, J. and C. Osuji. The Effect of Anticipated Transportation Improvement on Residential Land Values. *Regional Science and Urban Economics*, 1995, 25, 261–78.

McMillen, D. and J. McDonald. Reaction of House Prices to a New Rapid Transit Line: Chicago's Midway Line, 1983–1999. *Real Estate Economics*, 2004, 32, 463–86.

Mohring, H. Land Values and the Measurement of Highway Benefits. *Journal of Political Economy*, 1961, 79, 236–49.

Nelson, A.C. Effects of Elevated Heavy-Rail Transit Stations on House Prices With Respect to Neighborhood Income. In: *Transportation Research Record 1359, Planning and Administration: Economics, Finance, and Administration*. Transportation Research Board, National Research Council, National Academy Press, Washington D.C., 1992.

Sedway Group. Regional Impact Study. Report commissioned by Bay Area Rapid Transit District (BART). San Francisco, 1999.

Spengler, H.E. *Land Values in New York in Relation to Transit Facilities*. New York City, NY: Columbia University Press, 1930.

Voith, R. Changing Capitalization of CBD-Oriented Transportation Systems: Evidence from Philadelphia, 1970–1988. *Journal of Urban Economics*, 1993, 33, 361–76.

Von Thunen, J. *The Isolated State,* 1826.

Wang, K., T.V. Grissom, J.R. Webb, and L. Spellman. The Impact of Rental Properties on the Value of Single Family Residences. *Journal of Urban Economics*, 1991, 20, 152–66.

Workman, S. and D. Brod. Measuring the Neighborhood Benefits of Rail Transit Accessibility. *Transportation Research Record*, 1997, 1576: 147–53.

The views and conclusions expressed in this paper are those of the authors and do not necessarily reflect those of the Department of Housing and Urban Development.

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