# Impact of Transportation and Other Jurisdictional-Level Infrastructure and Services on Housing Prices

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**Abstract:** The existing literature, while estimating the impact of infrastructure and services, has tended to treat the housing market as homogeneous. This paper adds to the extant literature by systematically estimating the impact of selected jurisdictional-level public infrastructure and services—transportation accessibility (morning travel time to central business district; automobile accessibility to retail jobs), crime (violent crime rate), school quality (school expenditure per pupil), and overall quality of municipal-level infrastructure and services (overall municipal expenditure per person)—on various single-family housing submarkets. The single-family housing market is subdivided into four submarkets—existing high-quality housing; existing low-quality housing; new high-quality housing; and new low-quality housing. The data used in this paper include all the single-family housing sales recorded by the county tax assessor's office for 29 cities and towns of King County, Wash. from the years 1991 to 2000. The results show that the impact of the infrastructure and services depends upon the quality and age of the house. The findings suggest that the decrease in travel time to the central business district is likely to primarily benefit high-quality housing, while a decrease in violent crime rate is likely to equally benefit high- and low-quality housing. The increase in accessibility to retail jobs is valued by the residents of low-quality houses, while it may be considered a nuisance by the residents of high-quality houses. The findings on school quality suggest that the residents of high-quality houses are likely to value school quality more than the residents of low-quality houses. The per-person municipal expenditure is likely to benefit new housing two times as much as it would benefit existing housing.

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## Introduction

The jurisdictional-level infrastructure and services impact the price of housing in several ways. First, some infrastructure and services enhance the locational desirability of housing. For example, construction of a freeway at a distance of 3/4 km from a particular housing development increases the development's accessibility to other desirable uses such as work or shopping areas. Second, the infrastructure and services enhance the quality of life of the residents, and hence increase the demand for housing. For example, availability of pure water, a sewer connection, good schools, wide roads, and low crime increase housing prices. Third, the provision of infrastructure and services adds directly to the cost incurred by the local governments, and a fraction of these costs may be passed on to the developers responsible for bringing new housing supply to the market. Such costs may be passed on in the form of development exactions or impact fees. Fourth, property taxes and general obligation bonds have traditionally been used to fund jurisdictional-level infrastructure and services. These public finance mechanisms are based on the assumption that the funded infrastructure and services will benefit all the residents of the jurisdiction equally. To the extent the benefits are spatially unequally distributed (for example, infrastructure may be provided in the suburbs where newer development will benefit much more than the older inner-city development), housing prices may vary correspondingly. Many a times the newer suburban development is also of higher quality than the older inner-city development, so the provision of infrastructure and services may benefit newer, high-quality housing more than it benefits older, low-quality housing (Mathur 2006).

For the most part, the existing literature has treated housing as a homogeneous commodity, and failed to take into account the differential impacts of various infrastructure and services at the housing submarket level. This study, using the sales data for the single-family houses of 29 cities and towns of King County, Wash. sold between 1991 and 2000, advances the research by systematically estimating the impacts of jurisdictional-level infrastructure and services at housing submarket level.

### *Literature Review*

Structural and locational attributes of the house such as lot size, square footage of living space, quality of construction, age of the house, traffic noise, effect of proximity to landfills, air quality, and view were found to affect housing prices in research conducted by Benson et al. (1998), Clapp and Carmelo (1998), Clark and Nieves (1994), Thomas (1993), Dubin (1992), Nelson et al. (1992), Singell and Lillydahl (1990), Palmquist (1980), and Harrison and Rubinfeld (1978). Similarly, neighborhood-

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and jurisdictional-level attributes such as crime rates (Dubin and Sung 1990; Kain and Quigley 1970), education level (Dubin and Sung 1990; Kain and Quigley 1970), and racial composition (Brookshire et al. 1982; Dubin and Sung 1990; Kain and Quigley 1970); and regional demographic and economic drivers like interest rates (Pollakowski and Wachter 1990; Singell and Lillydahl 1990), population (Beaton 1991; Segal and Srinivasan 1985), and income (Fischel 1991) also affect housing prices.

Several studies have shown that the transportation infrastructure—in the form of a network of roads or the availability of public transportation such as buses or rail—significantly impacts housing prices. The published literature has typically used two types of measures, namely proximity- and accessibility-based measures, to estimate the impact of transportation infrastructure on housing prices. Studies using the first type of measures have, for example, looked at the impact of proximity to freeways on housing prices (see Kelly 1993 and Peiser 1989). Similarly, a study conducted by Benjamin and Sirmans (1994) found that every 0.16 km increase from a METRO station in Washington, D.C. led to a 2.50% decrease in apartment rents, while Bajic (1983), Joint Center for Urban Mobility Research (1987), Gatzalff and Smith (1993), Voith (1991), and Giuliano (1986) found that proximity to train service leads to an increase in the price of housing.

A second group of studies has used accessibility-based measures to estimate the impacts of transportation infrastructure on housing prices. The advantage of using accessibility-based measures over proximity-based measures is that while the latter studies specific components of the transportation infrastructure (just one freeway or one rail station at a time), the former treats it as an integrated system. The accessibility-based measures recognize the fact that, at the jurisdictional and metropolitan level, it is not the construction of one new rail station or the expansion of a stretch of one arterial road that would have a major impact—rather, the whole transportation system has a cumulative effect on overall accessibility within the region. A change in accessibility impacts housing prices. For example, Adair et al. (2000) examined the relationship between transportation accessibility and housing price in the Belfast region. Using the trip origination and destination data, the authors developed a gravity model to compute transportation accessibility by traffic zones. The study found that the effect of transportation accessibility on housing prices was insignificant at the city level but was significant at the housing submarket level. The study also found that accessibility had a significant effect on housing prices in lower-income neighborhoods.

While the amenity effect of the public infrastructure and services leads to an increase in housing prices, proximity to some forms of infrastructure may also be a disamenity. For example, while close proximity to highways provides increased regional access to the households and thus in turn increases the housing prices, it also has a disamenity effect due to the pollution and noise generated by the traffic (Langley 1976). Similarly, while access to high-quality social services, like education, leads to an increase in housing prices, physical proximity to schools may actually lead to a decrease in the price of housing due to the associated speed restrictions, and increased noise and traffic (Hendon 1973). Rosiers (2002) found that proximity to power lines, a clear nuisance, leads to substantial decrease in housing prices. While close proximity to some infrastructure and services (for example, highways and schools) may lead to disamenity effects, close proximity to others like parks, lakes, and open spaces may have both positive and negative effects. The overall result may be a net increase or decrease in housing prices, depending upon which influence outweighs the other. Molly (2001) examined the effect of proximity to different types of parks on housing prices and found that the value of proximity to a park varies with respect to park size and amenities. Small parks had the greatest impact on housing values, and the positive impact of proximity to small- and medium-size parks extended to homes as far as 472 m away.

Research by Chin and Foong (2006), Brasington (1999), Dubin and Sung (1990), Kain and Quigley (1970), Li and Brown (1980), and Oates (1969) has found that school quality systematically affects housing prices. Brasington (1999) examined various measures of public school quality in order to determine which input and output measures get capitalized into housing values. The study found that the proficiency tests scores (an output measure), and expenditure per pupil and the pupil/teacher ratio (both input measures) are consistently capitalized into housing prices. The study also found that teachers' salaries (an input measure) and student attendance rates (an output measure), though valued, are sensitive to the estimation technique used. Graduation rates (an output measure), teacher experience levels (an input measure), and teacher education levels (an input measure) are not consistently capitalized into housing prices. School expenditure was also found to significantly increase housing prices in research conducted by Bradbury (1997) and Mingche and Brown (1980). Brasington (2002) used the proficiency test scores as an indicator of school quality and found that, on average, each 1% increase in the proficiency test scores increased the price of the median house by $371.

Research estimating the effect of public infrastructure and services has to often use expenditures as proxies for the quality of infrastructure and services. Expenditures are used as the measure of output of aggregate public service bundle (McMillan and Carlson 1977). Two expenditure variables that are used most often include school expenditure per pupil and municipal expenditure per person. School expenditure is more likely to impact housing prices as it constitutes a significant proportion of the public expenditure at the municipal level, and also because it leads to an effect (increase in school quality) that is one of the most visible benefits for a large proportion of home buyers.

In summary, the review of published literature indicates that increase in school expenditure per pupil, municipal expenditure per person, transportation accessibility, and proximity to central business district positively impact housing prices, while increase in crime rate decreases housing prices. However, the existing research estimating the impact of jurisdictional-level infrastructure and services on housing prices has largely treated housing as a homogenous commodity. Preliminary evidence (for example Adair, et al. 2000) suggests that the impacts are likely to vary by housing submarkets. Put simply, housing markets are composed of smaller submarkets that depend on the age and quality of the house, and the same infrastructure or service may be valued differently by different housing submarkets. This paper aims to fill this gap in existing research through the estimation of the impact of selected jurisdictional-level infrastructure and services on housing of varying quality (high and low quality) and age (existing and new). The housing submarket level analysis would be useful for decision makers in charge of distribution and allocation functions of local governments. For example, a mayor might be interested in knowing whether investment in transportation infrastructure is going to impact all the residents equally (for example, would it have the same impact on high- and low-quality housing; or old and new housing?). Similarly, it may be important to know whether owners of high-quality housing would value the reduction in crime to the same extent as the owners of low-quality housing.

The remainder of this paper is divided into two sections. The first section "Study:" (1) describes the study area; (2) outlines the research approach; (3) describes the data collection and integration process; (4) estimates the impact of jurisdictional-level infrastructure and services on the prices of high- and low-quality housing; and (5) discusses the research findings. The second section "Conclusions" provides the conclusions.

## Study

This study estimates the effect of selected jurisdictional-level infrastructure and services on housing prices of high- and low-quality housing, as well as new and existing housing in King County, Wash. for the period 1991–2000. The geographical area of the study comprises 29 cities and towns of King County. King County forms a major part of the four-county Central Puget Sound region. The other three counties in the Central Puget Sound region are Snohomish County, Kitsap County, and Pierce County. As per United States Census 2000 (U.S. Bureau of Census 2000a), the county had a population of 1,737,034 in the year 2000, which was approximately more than half (52.12%) of the total population of the Central Puget Sound region, and more than a quarter (28.96%) of the total population of Washington State. The county accounts for a major share of Washington State's population and economy, and has a large and diverse housing market. Thus it presents a valuable setting for examining the effect of quality of jurisdictional-level infrastructure and services on housing submarkets.

### Research Approach

Estimation of the effect of various factors on the price of the house has long been theoretically and empirically discussed within a hedonic analysis framework pioneered by Rosen (1974). In this analysis, the price of the house is the sum of the implicit prices of the components of the bundle of housing services rendered by a housing unit.

The hedonic model used in this study is of the form

$$P_{ij} = f(S_i, L_i, J_k)$$

where: $P_{ij}$=selling price of the $i$th house in $j$th city or town; $S_i$=vector of structural attributes of the $i$th house; $L_i$=vector of locational attributes of the $i$th house; and $J_k$=vector of jurisdictional/regional attributes, including the jurisdictional-level public infrastructure and services.

The model is estimated using ordinary least squares regression. A semilog specification is used for the model estimation, with the log of the sale price of the house as the dependent variable. "The semilog specification has been widely used in prior hedonic regression studies, and is generally more robust than linear specifications that do not allow for diminishing marginal utility from increasing levels of attributes" (Mathur et al. 2004, pp. 1306–1307).

### Data Description

The data used in this study include all the single-family housing sales recorded by the county tax assessor's office for 29 cities and towns of King County, Wash. from the years 1991 to 2000. Tax assessor files for residential buildings, parcels, and real property sales were merged to create a data set that included the structural and locational attributes of the single-family houses sold over the study period. For King County these data were obtained from the Washington State Geospatial Data Archive (WAGDA). Only those sales transactions were included in the data set for which the sale year was between 1991 and 2000. In order to reduce the effects of outliers and the problem of miscoded extreme values, a filter was applied to drop the top and bottom 1% of the records on sale price, area of the house, and the lot. In addition, only houses with one to six bedrooms, and with at least one bathroom, were analyzed. The data set also contained information about the name of the jurisdiction in which the parcel was at the time of assessment. For the purpose of this study it was important to ascertain the jurisdiction in which the parcel was at the time of sale. For example a parcel "A" was in the city "X" at the time of tax assessment but was actually in the unincorporated area at the time of sale. To ascertain the jurisdiction of the parcel at the time of sale, the geographical information system (GIS) coverage of the parcel centroids was clipped with the annexation coverage to determine the jurisdiction to which the parcel belonged at the time of sale. GIS software was used to undertake spatial analysis to associate spatial features with parcel centroids, and to measure distances to key features such as the urban growth boundary, and urban centers.

Additional data on municipal expenditure, per pupil school expenditure, median income, population growth rate, mortgage rate, property tax rate, crime rate, and unemployment rate were collected for the period 1991–2000 and merged with the data set. The time series data allow control of the temporal variations that may affect the price of the house. Data on municipal expenditures were obtained from the Washington State auditor's office. Data on per-pupil school expenditure and GIS coverage of school districts were obtained from the Office of Superintendent of Public Instruction. Data on violent crime rates were obtained from the Washington Association of Sheriffs and Police Chiefs. Data on median income and population growth rate were obtained from the United States Census (U.S. Bureau of Census 1990a,b; 2000a,b). Data on unemployment rate, mortgage rates, and property tax rate were obtained from the Washington State Employment Security Division's web site, the Governor of the Federal Reserve System's website, and the Association of Washington Cities' Annual Tax and User Fee Survey data book, respectively.

Transportation accessibility factors were calculated using the transportation accessibility index constructed by Franklin and Waddell (2003) who used the Puget Sound Regional Council's regional transportation model to construct the transportation accessibility index at the transportation analysis zone (TAZ) level. This TAZ-level transportation accessibility data were integrated with the parcel-level data by first identifying the TAZ for each parcel. To estimate the effect of jurisdictional-level infrastructure and services on low- and high-quality housing, the dataset for King County was further subdivided based upon the quality of housing. The dataset had a variable measuring the quality of the structure. The quality variable included the following designations: poor, low, low average, average, fair, good, better, very good, and excellent. A house was considered high in quality if its quality was equal to or better than "good." A house was considered low in quality if its quality was less than or equal to "fair."

### Model Estimation

The data set consisted of 132,442 sales transactions. The 12,797 cases represented sales of new single-family houses (sale year is

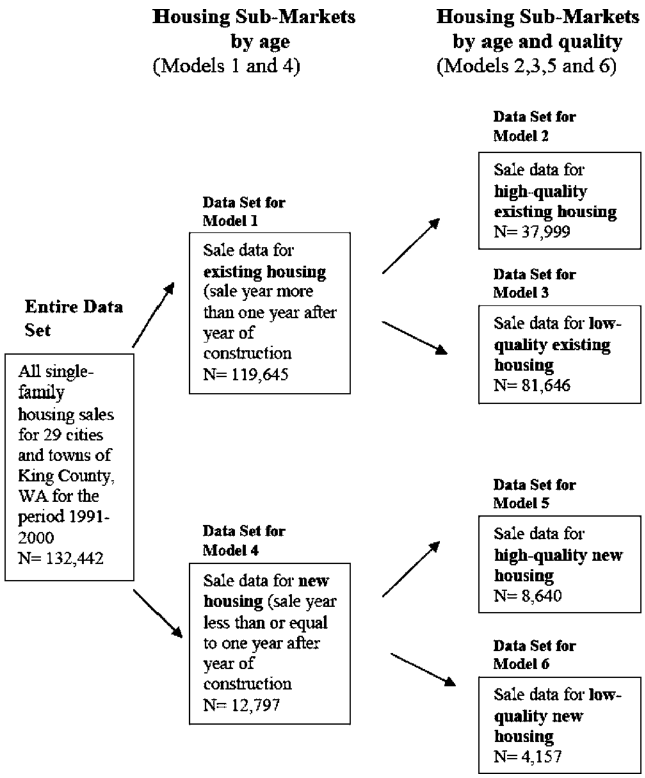


**Fig. 1.** Graphical representation of models

within 1 year after the year of construction), and the remaining 119,645 cases were sales of existing houses. Of the 119,645 existing housing sales, 37,999 sales transactions were of high-quality housing and the remaining 81,646 sales transactions were of low-quality housing. Of the 12,797 new housing sales, 8,640 sales transactions were of high-quality housing, and the remaining 4,157 sales transactions were of low-quality housing. Thus six separate hedonic models were estimated. The first model included observations for all the new single-family housing sales transactions. The second model included the observations for new high-quality single-family housing, the third model included observations for new low-quality single-family housing, the fourth model included observations for all existing single-family housing, the fifth model included observations for existing high-quality single-family housing, and the sixth model included observations for existing low-quality single-family housing sales transactions. Fig. 1 provides a graphical representation of the six models.

All the models had the log of sale price of the house as the dependent variable. Preliminary testing was done by analyzing the partial Pearson correlations and by checking for multicollinearity. Unemployment rate and income rate were dropped after running preliminary models due to the problem of multicollinearity. The sample stability of the models was tested by running the regressions on subsamples. The parameter estimates of the full sample and the subsamples were compared and found to be within 1 standard error of each other. Table 1 provides description of the variables used in the final models. Tables 2 and 3 provide descriptive statistics of the continuous variables used in the final models.

### *Discussion of Research Findings*

This section reports the findings of the empirical research. Table 4 provides the coefficients of the variables measuring the quality of jurisdictional-level infrastructure and services. The first column of Table 4 provides information about the variable measured. The rest of the columns provide the coefficients of the variable

**Table 1.** Description of Independent Variables Included in Final Models

| Variable | Description |
|---|---|
| (a) Structural attributes | |
| LOGSQMT | Log of square meter of living space |
| LOGLOT | Log of square meter of the lot size |
| BEDROOMS | Total number of bedrooms |
| (b) Locational attributes | |
| INVDISUGB | Inverse of distance to the urban growth boundary |
| INVDISCN | Inverse of distance to urban centers |
| (c) Locational attributes affected by jurisdictional-level transportation infrastructure | |
| LOGCBDA | Log of AM travel time to the central business district (CBD). This variable measures the degree of accessibility, by automobile, to the Seattle CBD |
| AUTORTAC | Log of auto retail job accessibility. This variable measures the degree of accessibility, by automobile, to the retail jobs |
| (d) Jurisdictional/regional attributes | |
| TAXRATE | Property tax rate (mill rate). |
| POPRATE | Annual rate of change in population of each jurisdiction |
| PERMITS | New single-family building permits issued per year in each jurisdiction |
| (e) Jurisdictional-level infrastructure and service attributes | |
| EXPERSON | Per capita municipal expenditure. Although not a direct performance measure, it measures the overall level of amenities and services in a municipality |
| EXPPUPL | Expenditure per pupil. This is a measure of the level of service of the school district |
| VCRATE | Total violent crimes per 1,000 people |

**Table 2.** Descriptive Statistics of Continuous Variables: Existing Single-Family Housing

| | All existing housing | | | | High-quality existing housing | | | | Low-quality existing housing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Minimum | Maximum | Mean | Std. Dev. | Minimum | Maximum | Mean | Std. Dev. | Minimum | Maximum | Mean | Std. Dev. |
| Sale price of the house | $45,300 | $769,000 | $199,731 | $101,308 | $50,000 | $769,000 | $282,789 | $119,269 | $45,300 | $760,000 | $161,075 | $60,948 |
| Lot size ($m^2$) | 243.96 | 12,302.41 | 815.44 | 636.01 | 243.96 | 12,180.98 | 989.65 | 798.90 | 244.15 | 12,302.41 | 734.37 | 524.43 |
| Total living space ($m^2$) | 63.17 | 393.91 | 157.10 | 60.76 | 65.03 | 393.91 | 212.85 | 57.09 | 63.17 | 385.55 | 131.15 | 42.11 |
| Total number of bedrooms | 1.00 | 6.00 | 3.15 | 0.88 | 1.00 | 6.00 | 3.54 | 0.81 | 1.00 | 6.00 | 2.97 | 0.85 |
| Property tax rate (mill rate) | 0.81 | 5.74 | 2.53 | 0.74 | 0.81 | 5.74 | 2.32 | 0.77 | 0.81 | 5.74 | 2.63 | 0.70 |
| Annual rate of change in population of each jurisdiction | −1.00 | 0.86 | 0.02 | 0.05 | −1.00 | 0.86 | 0.02 | 0.06 | −1.00 | 0.86 | 0.02 | 0.05 |
| New single-family building permits issued per year in each jurisdiction | 1.00 | 854.00 | 376.72 | 271.68 | 1.00 | 854.00 | 333.29 | 255.12 | 1.00 | 854.00 | 396.15 | 276.57 |
| Municipal expenditure per person | $209 | $9,846 | $2,018 | $1,160 | $209 | $9,656 | $1,837 | $1,083 | $209 | $9,846 | $2,103 | $1,184 |
| School expenditure per pupil | $4,360 | $19,890 | $6,708 | $1,081 | $4,360 | $12,515 | $6,592 | $1,053 | $4,360 | $19,890 | $6,762 | $1,090 |
| Total violent crimes per 1000 people | 0.00 | 16.43 | 6.39 | 4.23 | 0.00 | 16.43 | 5.02 | 4.16 | 0.00 | 16.43 | 7.03 | 4.10 |

**Table 3.** Descriptive Statistics of Continuous Variables: New Single-Family Housing

| | All new housing | | | | High-quality new housing | | | | Low-quality new housing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Minimum | Maximum | Mean | Std. Dev. | Minimum | Maximum | Mean | Std. Dev. | Minimum | Maximum | Mean | Std. Dev. |
| Sale price of the house | $52,000 | $765,000 | $245,115 | $104,584 | $55,000 | $765,000 | $283,232 | $104,687 | $52,000 | $543,000 | $165,892 | $39,964 |
| Lot size ($m^2$) | 245.64 | 12,261.81 | 820.66 | 490.13 | 246.84 | 12,261.81 | 877.34 | 540.51 | 245.64 | 7,528.21 | 702.85 | 334.33 |
| Total living space ($m^2$) | 74.32 | 393.91 | 211.10 | 55.71 | 106.84 | 393.91 | 232.25 | 50.99 | 74.32 | 322.37 | 167.14 | 35.91 |
| Total number of bedrooms | 1.00 | 6.00 | 3.54 | 0.64 | 1.00 | 6.00 | 3.61 | 0.62 | 1.00 | 6.00 | 3.40 | 0.65 |
| Property tax rate (mill rate) | 1.14 | 5.74 | 2.35 | 0.74 | 1.14 | 5.74 | 2.26 | 0.76 | 1.14 | 5.74 | 2.52 | 0.66 |
| Annual rate of change in population of each jurisdiction | −0.22 | 0.83 | 0.04 | 0.07 | −0.22 | 0.83 | 0.03 | 0.06 | −0.22 | 0.83 | 0.05 | 0.08 |
| New single-family building permits issued per year in each jurisdiction | 1.00 | 777.00 | 244.21 | 201.45 | 3.00 | 777.00 | 229.35 | 186.35 | 1.00 | 777.00 | 275.01 | 226.56 |
| Municipal expenditure per person | $209 | $9,846 | $1,640 | $947 | $209 | $7,791 | $1,612 | $843 | $209 | $9,846 | $1,698 | $1,129 |
| School expenditure per pupil | $4,360 | $12,515 | $6,404 | $1,409 | $4,360 | $12,515 | $6,406 | $1,474 | $4,837 | $12,515 | $6,400 | $1,272 |
| Total violent crimes per 1,000 people | 0.00 | 16.43 | 4.73 | 3.50 | 0.00 | 16.43 | 4.14 | 3.09 | 0.00 | 16.43 | 5.98 | 3.95 |

**Table 4.** Model Summary: Coefficients of Variables Measuring Jurisdictional-Level Infrastructure and Services

| | Housing/quality | | | | | |
|---|---|---|---|---|---|---|
| Variables | New/all | New/high | New/low | Existing/all | Existing/high | Existing/low |
| LOGCBDA | $-0.072^{c}$ | $-0.125^{c}$ | $0.254^{c}$ | $-0.200^{c}$ | $-0.377^{c}$ | $0.068^{c}$ |
| AUTORTAC | $1.05\times10^{-5a}$ | $-8.95\times10^{-6}$ | $1.10\times10^{-4c}$ | $1.01\times10^{-5b}$ | $-4.83\times10^{-5c}$ | $9.33\times10^{-5c}$ |
| VCRATE | $0.004^{c}$ | $0.011^{c}$ | $0.007^{c}$ | $-0.015^{c}$ | $-0.006^{c}$ | $-0.014^{c}$ |
| EXPPUPL | $-3.71\times10^{-7}$ | $5.71\times10^{-7}$ | $-5.34\times10^{-6b}$ | $4.01\times10^{-6c}$ | $7.08\times10^{-6c}$ | $3.76\times10^{-6c}$ |
| EXPERSON | $2.12\times10^{-5c}$ | $1.90\times10^{-5c}$ | $-1.07\times10^{-5a}$ | $1.19\times10^{-5c}$ | $6.11\times10^{-6}$ | $1.31\times10^{-5c}$ |

[a]Significant at $p=0.1$.
[b]Significant at $p=0.05$.
[c]Significant at $p=0.01$.

obtained from various models. For detailed results please see Table 5. The hypothesized relationships and the model findings are discussed below.

### Natural Log of Morning Auto Travel Time to Central Business District (CBD) (LOGCBDA)

LOGCBDA is a measure of automobile accessibility to CBD. In this study it measures accessibility to the Seattle CBD. Seattle is the biggest city in Washington State and downtown Seattle is the major employment center of the region. It is hypothesized that a decrease in travel time to employment center would increase housing prices. Furthermore, higher-income households are more likely to live in high-quality housing and thus have a greater time value of money than their lower-income counterparts. Hence, it is further hypothesized that compared to low-quality housing, the decrease in travel time would lead to a larger increase in the price of high-quality housing. The models' findings for high-quality housing confirm the hypotheses. The results (see Table 4) indicate that every 1% decrease in travel time to CBD leads to 0.072% increase in the price of all new housing. The increase is 0.125, 0.254, and 0.377% for new high-quality housing, all existing housing, and existing high-quality housing, respectively. For a $200,000 house this amounts to an increase of $250, $508, and $754 in the price of all new housing, all existing housing, and high-quality existing housing, respectively. However in the case of low-quality housing—existing as well as new housing—the price decreases as travel time to CBD decreases. This counterintuitive finding may suggest that a large proportion of low-quality housing close to downtown Seattle is low priced. Such low-quality, low-priced housing can typically be found in low-income neighborhoods in and around downtowns of most large cities in the United States, and downtown Seattle is no exception to this phenomenon. In any case, the overall findings suggest that high-quality houses are likely to be the primary beneficiaries of the decrease in travel time to CBD.

### Auto Accessibility to Retail Jobs (AUTORTAC)

Retail jobs typically pay low to medium wages. When compared to the residents of high-quality housing, residents of low-quality housing are likely to work in retail jobs and thus would benefit from increased transportation accessibility to such jobs. Hence proximity to retail jobs is more likely to increase the price of low-quality housing. Furthermore, traffic congestion and noise pollution—both factors likely to negatively influence price of high-quality housing—might increase as proximity to retail jobs increases. Hence increased accessibility to retail jobs might decrease the price of high-quality housing. The model's findings substantiate the hypothesis. The findings show that increase in auto accessibility to retail jobs increases the price of existing low-quality housing and new low-quality housing, while it depresses the price of new high-quality housing and existing high-quality housing (see Table 4).

### Violent Crime Rate (VCRATE)

Incidence of violent crimes is expected to decrease the price of all types of housing. In the models run for this study, the violent crime rate variable has the expected negative sign for the existing housing, and unexpected positive sign for new housing. The unexpected positive sign may be a result of data artifact, or representative of the fact that some of the new housing has developed in higher crime jurisdictions. Analysis of the impact of violent crime rate on existing housing shows that the decrease of one violent crime per 1,000 population per year decreases housing price by 1.5, 0.6, and 1.4% for all existing housing, high-quality existing housing, and low-quality existing housing, respectively. For a $200,000 house this translates into a decrease of $3,000, $1,200, and $2,800 for all existing housing, high-quality existing housing, and low-quality existing housing, respectively. In King County, the average violent crime rate was 6.4 per 1,000 people between 1991 and 2000, with a minimum of 0 and a maximum of 16.4 violent crimes reported per 1,000 people. This means that if a town there was to go from being high in crime to being medium in crime—from a violent crime rate of 16.4 per 1,000 to a violent crime rate of 6.4 per 1,000, a 61% decrease—the price of a $200,000 existing house would, on average, increase by $30,000, a 15% increase. Schwartz et al. (2003) found a similar impact of violent crime rates on housing prices. During the period 1988–1998, a 53% fall in violent crime rate contributed to an 8% rise in housing prices in New York City. Haurin and Brasington (1996) found an elasticity of home values with respect to crime rates of negative 0.05, which translates into a $10,000 depreciation of a $200,000 house if the crime rate doubles.

### School Expenditure per Pupil (EXPPUPL)

The variable, school expenditure per pupil, measures the quality of the school district. Thus an increase in school expenditure per pupil is likely to result in higher prices for all housing types. It is likely that the residents of high-quality housing are also higher-income and higher-education households compared to the residents of low-quality housing. Hence, compared to the residents of low-quality houses, the residents of high-quality houses are more likely to put a bigger premium on the quality of the school district. Therefore, it is hypothesized that increase in school expenditure is likely to benefit high-quality houses more than low-quality houses. In the models run for this study, the coefficient of the variable EXPPUPL has a positive sign for existing housing signifying that the increase in the quality of school district in particular, and the bundle of jurisdictional-level infra-

**Table 5.** Regression Results[a]

| | All existing Model 1 | High-quality existing Model 2 | Low-quality existing Model 3 | All new Model 4 | High-quality new Model 5 | Low-quality new Model 6 |
|---|---|---|---|---|---|---|
| Constant | 8.712[d] | 9.204[d] | 9.077[d] | 7.494[d] | 7.765[d] | 8.451[d] |
| (a) Structural attributes of the house | | | | | | |
| LOGSQMT | 0.747[d] | 0.731[d] | 0.490[d] | 0.855[d] | 0.869[d] | 0.435[d] |
| LOGLOT | 0.056[d] | 0.103[d] | 0.013[d] | 0.072[d] | 0.056[d] | 0.036[d] |
| BEDROOMS | −0.050[d] | −0.054[d] | −0.020[d] | −0.055[d] | −0.047[d] | −0.006 |
| (b) Locational attributes | | | | | | |
| INVDISUGB | 0.001[d] | 0.001[c] | $4.08\times10^{-4}$[c] | $-1.79\times10^{-4}$ | $-1.7\times10^{-4}$ | $1.9\times10^{-4}$[c] |
| INVDISCN | 0.141[d] | 0.069[d] | 0.072[d] | 0.146[d] | 0.171[d] | 0.028 |
| (c) Jurisdictional/regional attributes | | | | | | |
| TAXRATE | −0.012[d] | −0.005 | −0.010[d] | −0.009[b] | −0.014[c] | −0.005 |
| POPRATE | 0.052[d] | 0.038 | 0.063[d] | 0.038 | 0.001 | −0.010 |
| PERMITS | $3.78\times10^{-5}$[d] | $1.32\times10^{-4}$[d] | $6.06\times10^{-5}$[d] | $5.93\times10^{-5}$[c] | $1.80\times10^{-5}$ | $9.9\times10^{-5}$[d] |
| (d) Locational attributes affected by jurisdictional-level transportation infrastructure | | | | | | |
| LOGCBDA | −0.200[d] | −0.377[d] | 0.068[d] | −0.072[d] | −0.125[d] | 0.254[d] |
| AUTORTAC | $1.01\times10^{-5}$[c] | $-4.83\times10^{-5}$[d] | $9.33\times10^{-5}$[d] | $1.05\times10^{-5}$[b] | $-8.95\times10^{-6}$ | $1.10\times10^{-4}$[d] |
| (e) Jurisdictional-level infrastructure and service attributes | | | | | | |
| EXPERSON | $1.19\times10^{-5}$[d] | $6.11\times10^{-6}$ | $1.31\times10^{-5}$[d] | $2.12\times10^{-5}$[d] | $1.90\times10^{-5}$[d] | $-1.07\times10^{-5}$[b] |
| EXPPUPL | $4.01\times10^{-6}$[d] | $7.08\times10^{-6}$[d] | $3.76\times10^{-6}$[d] | $-3.71\times10^{-7}$ | $5.71\times10^{-6}$ | $-5.34\times10^{-6}$[c] |
| VCRATE | −0.015[d] | −0.006[d] | −0.014[d] | 0.004[d] | 0.011[d] | 0.007[d] |
| (f) Season dummies | | | | | | |
| WINTER | −0.041[d] | −0.040[d] | −0.041[d] | −0.052[d] | −0.063[d] | −0.036[d] |
| SPRING | 0.001 | $2.36\times10^{-4}$ | −0.004 | −0.027[d] | −0.034[d] | −0.017[d] |
| SUMMER | −0.002 | −0.004 | −0.002 | −0.103[d] | −0.016[d] | −0.008 |
| (g) Year dummies | | | | | | |
| YR92 | 0.029[d] | 0.015[c] | 0.034[d] | 0.001 | −0.012 | 0.050[d] |
| YR93 | 0.037[d] | 0.011 | 0.048[d] | 0.013 | −0.004 | 0.069[d] |
| YR94 | 0.062[d] | 0.055[d] | 0.070[d] | 0.059[d] | 0.039[d] | 0.118[d] |
| YR95 | 0.046[d] | 0.069[d] | 0.054[d] | 0.090[d] | 0.086[d] | 0.143[d] |
| YR96 | 0.089[d] | 0.111[d] | 0.092[d] | 0.124[d] | 0.117[d] | 0.184[d] |
| YR97 | 0.162[d] | 0.184[d] | 0.160[d] | 0.172[d] | 0.160[d] | 0.218[d] |
| YR98 | 0.261[d] | 0.291[d] | 0.259[d] | 0.250[d] | 0.244[d] | 0.280[d] |
| YR99 | 0.340[d] | 0.366[d] | 0.337[d] | 0.318[d] | 0.321[d] | 0.374[d] |
| YR2000 | 0.437[d] | 0.457[d] | 0.433[d] | 0.402[d] | 0.391[d] | 0.465[d] |
| (h) Jurisdiction dummies | | | | | | |
| ALOGNA | −0.265[d] | — | −0.328[d] | −0.122[d] | — | −0.277[d] |
| AUBURN | −0.146[d] | −0.161[d] | −0.241[d] | −0.023 | −0.061[c] | −0.186[d] |
| BELLEVUE | 0.007[d] | −0.031[d] | 0.002 | 0.362[d] | 0.298[d] | 0.113[d] |
| BLACKDIA | −0.139[d] | −0.002 | −0.211[d] | 0.059[c] | 0.113[b] | −0.121[c] |
| BOTHELL | −0.015[d] | −0.031[d] | −0.035[d] | 0.191[b] | 0.156[d] | 0.085[d] |
| BURIEN | −0.209[d] | — | −0.160[d] | — | — | — |
| CARNATION | 0.045[c] | −0.016 | −0.041[b] | 0.128[b] | 0.100[c] | −0.012 |
| CLYDEHILL | 0.316[d] | 0.256[d] | 0.395[d] | — | — | — |
| COVINGTON | −0.135[d] | −0.140[d] | −0.204[d] | — | — | — |
| DESMOINES | −0.183[d] | −0.173[d] | −0.124[d] | −0.027 | −0.061[b] | −0.004 |
| DUVALL | 0.040[d] | 0.014 | 0.004 | 0.158[b] | 0.150[d] | 0.027 |
| ENUMCLA | −0.105[d] | −0.059[c] | −0.227[d] | −0.030 | −0.042 | −0.224[d] |
| FEDERALW | −0.138[d] | −0.158[d] | −0.202[d] | 0.022[d] | −0.029 | −0.170[d] |
| ISSAQUAH | −0.008 | −0.048[d] | 0.056[d] | 0.376[d] | 0.289[d] | 0.164[d] |
| KENT | −0.222[d] | −0.262[d] | −0.210[d] | −0.059[d] | −0.097[d] | −0.097[d] |
| KIRKLAND | — | — | — | 0.231[d] | 0.191[d] | 0.107[d] |
| LAKEFORE | −0.046[d] | −0.107[d] | 0.015 | — | — | — |

**Table 5.** (*Continued.*)

| | All existing Model 1 | High-quality existing Model 2 | Low-quality existing Model 3 | All new Model 4 | High-quality new Model 5 | Low-quality new Model 6 |
|---|---|---|---|---|---|---|
| MEDINA | 0.345[d] | 0.289[d] | 0.450[d] | — | — | — |
| MILTON | −0.174[c] | — | −0.220[c] | — | — | — |
| MAPLEVA | −0.074[d] | −0.048[c] | −0.103[d] | — | — | — |
| PACIFIC | −0.199[d] | −0.244[d] | −0.246[d] | — | — | — |
| REDMOND | −0.040[d] | −0.029[d] | −0.039[d] | 0.214[d] | 0.165[d] | 0.205[c] |
| RENTON | −0.150[d] | −0.180[d] | −0.124[d] | 0.067[d] | 0.001 | 0.050[d] |
| SHORELINE | −0.048[d] | −0.109[d] | −0.075[d] | 0.129[d] | 0.090[c] | 0.089[d] |
| SKYKOMISH | 0.101 | 0.116 | — | — | — | — |
| SEATAC | −0.235[d] | −0.251[d] | −0.180[d] | −0.070[d] | −0.079[c] | −0.118[d] |
| TUKWILA | −0.192[d] | −0.207[d] | −0.152[d] | −0.112[d] | −0.216[d] | −0.045[c] |
| WOODINVI | 0.043[d] | −0.004 | 0.029[c] | — | — | — |
| YARRROW | 0.379[d] | 0.301[d] | 0.472[d] | — | — | — |
| Model statistics | | | | | | |
| Number of observations | ***119,645*** | ***37,999*** | ***81,646*** | ***12,797*** | ***8,640*** | ***4,157*** |
| Adjusted $R^2$ | ***0.655*** | ***0.605*** | ***0.562*** | ***0.799*** | ***0.734*** | ***0.722*** |

[a]The dependent variable is the natural log of the sale price of the house.
[b]Significant at $p=0.1$ *level*.
[c]Significant at $p=0.05$ *level*.
[d]Significant at $p=0.01$ *level*.

structure and services in general, leads to an increase in the price of existing housing. However, the effect of the variable is statistically insignificant for all new housing and high-quality new housing, and unexpectedly negative for the low-quality new housing (see Table 4). This counterintuitive negative sign may suggest that a substantial proportion of new low-quality housing is being produced in areas where the school districts have lower per pupil school expenditure.

The models run for this study show that for $200,000 existing homes, $1 increase in school district expenditure leads to an increase of $0.82, $1.41, and $0.75 in the price of all existing homes, existing high-quality homes, and existing low-quality homes, respectively. The result for existing housing indicates that school district expenditure benefits high-quality housing twice as much as it benefits low-quality housing.

### Municipal Expenditure per Person (EXPERSON)

The variable measuring the amount of per-person municipal expenditure measures the quality of the bundle of jurisdictional-level infrastructure and services. Thus an increase in per-person municipal expenditure is likely to result in higher prices for all housing types. In the models run for this study, the coefficient of the variable EXPERSON has a positive sign for all new housing, new high-quality housing, all existing housing, and existing low-quality housing. The impact is statistically insignificant (though positive) for existing high-quality housing, and negative for new low-quality housing. For the new housing, every $1 increase in per-person municipal expenditure increased the price of a $200,000 new house by $4,240. However when parsed by housing quality, the models show that the price of $200,000 new high-quality houses increased by $3,800, and the price of $200,000 new low-quality houses decreased by $2,140. Also, the results show that prices of new houses are likely to increase twice as much as the prices of existing houses. As discussed earlier in this paper, if a large proportion of residential development occurs in the suburbs in the form of high-quality housing then this housing type is more likely to benefit from investment in jurisdictional-level infrastructure and services compared to the existing housing and new low-quality housing. In the case of existing housing, and to the extent new low-quality housing is in already urbanized areas, a larger proportion of municipal expenditure may go towards maintenance and operations, which may not lead to significant improvement in the quality of the jurisdictional-level infrastructure and services. Indeed, the period 1991–2000 was one of rapid suburban expansion in King County where the smaller suburban cities like Bellevue, Bothell, Kent, and Redmond invested in municipal-level infrastructure and services and attracted primarily high-quality housing.

## Conclusions

The jurisdictional-level infrastructure and services impact housing prices. The existing studies have shown that crime rates, education level, accessibility to freeways, proximity to lakes, parks, and transit facilities affect the price of housing. However, most of the studies do not explore the impact of these infrastructure and services at the housing submarket level. This paper advances research by systematically estimating the impact of four key infrastructure and service variables—transportation accessibility (measured by two variables: auto accessibility to CBD and auto accessibility to retail jobs); safety (measured by violent crime rate); school quality (measured by per-pupil school expenditure); and overall quality of jurisdiction (measured by per-person municipal expenditure)—at the housing submarket level. This research finds that the impact of infrastructure and services differ based on the quality and age of the house. The findings suggest that the decrease in travel time to CBD would primarily benefit high-quality housing, while a decrease in violent crime rate would benefit both high- and low-quality housing. The increase in accessibility to retail jobs is valued by the residents of low-quality houses, while it may be considered a nuisance by the residents of high-quality houses. The findings on school quality suggest that the residents of high-quality houses are likely to value school quality more than the residents of low-quality houses. The per-person municipal expenditure is likely to benefit new housing twice as much it would benefit existing housing. This may be attributed to the fact that in the case of new high-quality housing, municipal expenditure often results in provision of new infrastructure and services, while in the case of existing housing it is often used for maintenance-related projects that may not result in a tangible increase in the quality of infrastructure and services.

In the future, researchers can conduct similar housing submarket level studies for other metropolitan areas. The findings of this and future studies can have significant value for officials in charge of distribution and allocation functions of local governments. The officials can use the research findings to assess the outcomes of a particular infrastructure- or service-related investment decision by identifying the resident groups likely to benefit from the investment decision. This information may in turn help target public outreach to potential opponents, and strengthen support by making the potential supporters aware of the investment decision. Furthermore, in the current fiscal climate where most of the local jurisdictions are strapped for funds, the research findings can help jurisdictions compare the impacts of their investment decisions across multiple infrastructure and service sectors. For example, a jurisdiction can estimate the net benefits, and the potential beneficiaries, of each $1 million investment in schools, police protection, and transportation.

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