The Value of Bus Rapid Transit: Hedonic Price Analysis of the EmX in Eugene, Oregon

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Abstract

Transportation investments can increase the welfare of a city or region in order to create economic development. Often public transportation has the potential for economic development in three ways; sustaining and maintaining dense development and growth in the downtown core; allocating land use and development; creating and stimulating economic growth and employment opportunities. These are measured along the transit line through increase in property values, increased development projects, and changes in business activity (Neuwirth, 143). Other contributing factors to transit decisions include objectives and values, effects on various groups, downtown development and environmental quality. Different modes accomplish these goals with various efficiencies depending on their characteristics. This paper will introduce an examination of the bus rapid transit (BRT) line in the Eugene area based on changes in residential property values. Specifically, the purpose is to determine benefits in terms of the property values changes before and after the implementation of the line. We considered residential sale prices from 2002-2012 and analyzed trends of house values across varying distances. We found a significant, negative correlation between distance from a property and the Franklin EmX line. There was no significant trend to draw from in regards to the Gateway extension but this value may have simply not had enough time to capitalize into the surrounding properties. We then applied our model to sale prices within a 60 minute walk of the Franklin line to perform a cost/benefit analysis that can be considered for future BRT lines including the westward expansion of the EmX in Eugene.

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I. Introduction

IA. Bus Rapid Transit: Defined

BRT is briefly defined by the Federal Transit Administration as "a rapid mode of transportation that can combine the quality of rail transit and the flexibility of buses" (Thomas). The main idea of BRT is to combine the flexibility and lower implementation costs of bus transit along with the comfort and efficiency of light rail transit (LRT). It is an integrated system of facilities and services that result in a faster, more reliable mode of transportation than a bus line. It decreases wait times because it has off-board fare collection and often runs on exclusive rights. The cost is about one third that of an LRT line and the travel time saving is generally 2-3 minutes per mile for buses on grade separated right-of-way (Herbert). Savings are most noticeable where buses had previously experienced congestion. Several common characteristics of BRT lines are as follows:

- Exclusive rights of way
- Quick boarding and off-board fare collection
- Use of intelligent transportation systems
- Lower travel time
- Greater reliability and higher frequency
- Distinctive label and marketing
- Increased safety and security
- Greater capacity
- Capital/operating cost effectiveness
- Possible increased environmental quality

The result is a low cost transportation mode that derives a number of benefits from the more expensive mode of LRT, generating greater ridership and overall ease of transportation compared to standard bus systems.

Performance from the implementation of BRT lines can mostly be measured in terms of passenger growth and travel speeds/time savings. Past studies have found increased ridership;

for example Los Angeles found a 26-33% gain (1/3 of which were new riders) (Herbert). They have also found increased speed; using the Los Angeles example again, a study found a travel time savings of 23-28% compared to the metro bus, which was originally in place.

IB. History and Implementation of BRT

Before the 1920s, the streetcar was the dominant form of public city transportation, peaking nationally at a level of 72,911 streetcars in 1917. In the 1920s however, smaller cities began replacing their streetcars with buses, larger cities started making the same transition several years afterwards. The first signs of BRT elements appeared as early as 1939 when Chicago introduced the first exclusive bus lane in the United States. Growing traffic congestion and increasing bus-operating costs began to send standard bus lines into a negative cycle that was reflective of the decline of the streetcar. To combat this, planners started looking towards alternative transportation methods. Pittsburgh, Pennsylvania introduced their South Busway in 1977, the first US BRT prototype (based off of the Curitiba, Brazil model). This line saw great success and is still operating today. There were other prototype lines such as the Silver Streak BRT in Los Angeles. However, they did not catch large public awareness because attention was drawn to flashier metro systems. It was not until the 1990s that a second wave of BRT interest sprang up, due mostly in part from actions by the W. Alton Jones Group. Since then, BRT has continued to emerge in developing countries such as Latin America, Asia, and Africa demonstrating the efficiency that it can provide. However, the number of BRT systems in the United States still remains very limited along with a low level of public awareness and apathy.

IC. Our Case: EmX Line, Eugene OR

Our study focuses specifically on the EmX line placed in the Springfield/Eugene area. Planning for the EmX BRT system began in 1996 when planners needed to address congestion problems caused by Oregon’s urban growth boundary (UGB). A UGB limits the amount of urban expansion allowed beyond a city's core to avoid sprawl. Within the UGB, the policy can lead to dense development and potential for congestion. In a planning document from the city of Eugene, it is projected that over the next 20 years population will grow by approximately 20%, but the increase to the UGB will be by only 3%. That is, the estimated population density will increase from about 5.19 persons per acre to 5.98 (Envision Eugene). Eugene needed a transit option that would reduce single occupancy vehicle trips in the city.

BRT was identified as the preferred mode of choice because of its enhanced transit service benefits with relatively low costs. It was approved in 2001 as “a key element of the new transportation plan by Eugene, Springfield, Lane County, and LTD” (LTD). EmX service began in 2007 with the introduction of the Franklin Line, which connected downtown Eugene to downtown Springfield along with the University of Oregon. After a year of service, it was estimated to have carried 1.5 million riders. This growing trend of ridership continued and in 2009 it carried its 4 millionth rider.

The Franklin Line operates on a 4-mile long corridor with 10 stations and exclusive right-of-way for 60% with a total travel time of 16 minutes one-way. The second corridor began operations in January 2011. This new line called the Gateway EmX extended the existing service to Gateway, PeaceHealth Riverbend Facility, and the Gateway business district. The Gateway EmX runs on a 7.8 mile corridor with 5.2 miles being exclusive right of way (66%). It has 14 stations and an estimated round trip travel time of 40 minutes (Image A). LTD is currently looking to expand a new corridor to serve the needs of West Eugene.

II. Literature Review

IIA. Transit oriented development

Transit oriented development (TOD) is increasingly supported by planners to address a multitude of problems with the current urban form. It is defined as "compact, mixed-use development near transit facilities that is generally associated with high-quality walking environments." In respect to TOD, BRT is compared to LRT due to the fixed infrastructure (Catalá and Perk). A fixed guideway transportation system creates opportunities at stops for increased development. This can alter the land use pattern and affect growth on a larger scale. The most accessible places within a city are likely to foster development and high land values (Emerson 150). Theoretically, fixed guideway transit is able to redistribute dense economic development in an efficient manner.

Although there have not been extensive studies completed on the property value effects of BRT, there have been similar studies completed on the effects of LRT. Since the main difference between these two modes is the implementation costs, they can serve as useful comparisons for reference points. There have been as many as 50 studies completed since the 1970s on this topic (Duncan). Based on these studies, evidence points to single-family properties near the station selling at premiums of upward to 10%. A handful of other studies have involved multi-family homes as well as commercial properties. These findings showed a slightly greater premium than single-family units. Duncan explores even further to find external effects outside of the benefits from Transit Oriented Development (TOD), such as the conditions of pathways/neighborhoods that lead up to stations. A cross-sectional hedonic price model is used in this study to isolate and discover the impact of TOD compared to the sum of its components on condominium prices in the San Diego area. They found the hypothesis to be valid that “proximity to a rail station adds more to the value of a property in a good pedestrian environment than it does to a property in a bad pedestrian environment” (Duncan). In our experiment, we will create variables to capture the effects that the neighborhood may have on BRT value.

The increase in accessibility is a public good; however the externality of the actual corridor on property values should be accounted for. This externality includes pollution and the possibility of increased crime rates (Kilpatrick et. al). Properties immediately on the corridor may experience negative impacts. Yet, the nature of fixed guideway systems is likely to affect land use immediately adjacent to stations, such as greater pedestrian and bicycling infrastructure (Emerson 153). This causes increased walkability and rapid, timely access to other parts of the city, especially the central business district. The central business district attracts value by being closer in proximity to a hub of activity, particularly in older metropolitan regions. Development density is essential to this factor (Bartholomew and Ewing 22). The accessibility increases travel options for residents, which in theory is translated into increased development and property values (Fejarang). Therefore, literature suggests that proximity to bus rapid transit will be capitalized in increased property values of surrounding residential and commercial facilities, excluding immediately adjacent properties.

IIB. Case Study: Pittsburgh, Pennsylvania

Few studies have been done specifically on BRT. In one that does focus on BRT in Pittsburgh's Martin Luther King, Jr. East Busway, researchers Martin Catalá and Victoria A. Perk (2009) found that the relationship between the distance to a station and property value is inverse (decreasing as distance from a station increases). In the perspective of the Eugene/Springfield EmX, it is important to note that differing characteristics of cities affect the viability of transit. The ability to utilize public transportation is inhibited by spread out land uses, especially because it is most efficient in areas of high density (Laube and Litman, 3). This is seen regionally, where western and southern states have lower transit ridership due to less dense development patterns (Kain, 366). The study specifically notes that its CBD is an area of high employment and the city's density limits highway transportation and parking options. Therefore, not all of the outcomes can be generically applied to the BRT in the Eugene/Springfield study.

The study looked at single-family residences in the proximity of the BRT corridor. Background information explained that the East Busway is one of the oldest systems after being implemented in 1983. The study is conducted 26 years after implementation. It is reasonable that changes in travel choice have already been established and any development due to the transportation system has already occurred. The study used a hedonic price regression model to examine the marginal effect of distance to a BRT station on property values at a single point in time through a cross-sectional analysis. It was preferred to use a before and after scenario, but the data limited the study (41). Under the assumption that there are accessibility benefits when in proximity to a transit station, they hypothesized that benefits would be capitalized into land values.

The model used the dependent variable of appraised property value as a function of four independent variables; “The four vectors are *D*, a vector of variables that measures the distance of parcels to transit stations; *H*, a vector of variables that describes housing characteristics; *L*, a vector of variables that describes location amenities; and *N*, a vector of variables that describes neighborhood characteristics (42).” As the mean effect on appraised value changes by one unit, the effects from the corresponding coefficients were examined.

Results found that as the distance to a station increased, the property value of the parcel decreased. Precisely, “moving from 101 to 100 feet away from a BRT station, property value of a single-family home increases approximately $19.00. Moving from 1,001 to 1,000 feet away from a station increases property value approximately $2.75” (58). Issues with the data included spatial autocorrelation causing upward bias and heteroskedasticity that was corrected for. The overall results are limited to the Pittsburgh case, but act as a starting point.

III. Methodology

IIIA. Defining the Question

Overall, this study examines the economic impact of implementing a BRT system into the Eugene/Springfield area. This will be realized in the value capitalized into residential property values depending on distance. We begin by using the time variable of years to use as our control to estimate the effect of a new bus rapid transit line on the value of residential properties within proximity of a sixty minute walk. We will account for differences in attributes of the homes, neighborhood location based on stops, as well as the year in which they were sold.

As mentioned, few studies have been done on the impact of BRT on economic development. “Experience is not yet widespread enough to draw conclusions on the factors that would result in even greater development benefits from BRT investment, although the general principle that good transit and transit support of land uses are mutually reinforcing should hold” (NBRTI, 5-6). Based on previous studies and the assumption that being in proximity to a BRT station is valued, it is hypothesized that distance from the BRT stations will have an inverse effect on property value. That is, as distance to the line decreases, property values will increase.

The inquiry will be conceptualized through hedonic modeling techniques. Hedonic modeling is based on Lancaster’s (1966) theory of consumer demand. The theory states that the market value of a good is determined by the value of its combined characteristics. “Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them” (Rosen, 34). This fact gives a relationship between the market equilibrium and consumer theory. Hedonic modeling serves as a market clearing function that defines the market value of a good as a function of a single equation. Property value is therefore a function of an aggregation of the characteristics of the actual lot, and is combined with factors of the given physical and environmental surroundings of the location (Kuethe). The following will explain how this is applicable in the EmX study at hand.

IIIB. Model Specification

The value of the property will be examined to estimate the marginal change in value before and after a new BRT system is implemented (Catalá and Perk). The study is a cross-sectional and time series analysis of the local area between the years of 2002-2012. The model will examine the BRT systems at Franklin Boulevard and the Gateway extension in the Eugene/Springfield area (Image A).

The dependent variable in the model is tax lot data on property value (P). The independent variables factors are within three categories: distance to transit (D), housing characteristics (H), and time variables measured in years (Y). The specific factors are outlined in detail at a later point. A preliminary model outline is as follows:

$$Ln(P) = H + d + BRTdummy + BRTdummy * d + \text{year dummies}$$

IIIC. Data Specification

The source of a large portion of the data comes from the Regional Land Information Database (RLID) of Lane County. RLID is a data warehouse of land use information for the county. The data is organized by maplot, address and longitude/latitude coordinates. It gives the value of the sale price based on the year the transaction was documented. For each of the roughly 110,000 observations there are a variety of attributes describing the particular property.

Using a Stata program that incorporates Google maps, we found the nearest EmX stop for all observations. From this calculation, we were able to generate distance variables linking observations to corresponding stops. This will be discussed in more detail at a later point in the paper.

For our study, only observations that were within a two mile straight-line radius of the bus line were included in the regression. We created an area surrounding the bus lines that extended two miles beyond the furthest stop in each compass direction (Image B). The range of walking times for the Franklin corridor fell between 0-125 minutes. The Gateway line had a smaller range of walking times, taking on values from 0-81 minutes. Due to the wide range in property values, we winsorized the data to eliminate several outliers that would bias our coefficients. We eliminated the top and bottom .002% of sale prices. This dropped values with sale prices smaller than $22,501 and greater than $16,100,000; 125 observations in total. After dropping out observations that were beyond the range of expected effects from the bus lines, we were left with 24,506 observations. In order to study Franklin and Gateway separately, we divided the observations into the corresponding line depending on the stop. This split the data into 12,922 observations for Franklin and 11,584 into Gateway. Yearly dummy variables will represent the before and after implementation of the EmX by only interacting the sales after 2007 with the minimum distance value.

Due to the time frame, one issue that arises is the housing market crash in 2007. By including yearly dummy variables, we are able to control for such housing market trends as well as implementation of the EmX. Another approach to the problem is to find a control group to compare the corridors against. This can be done by extending beyond the distance of house values being affected by the EmX implementation. Using a matching market serves as the control group for comparison purposes to isolate for variables that are not captured in the model. Further, the Gateway EmX line started serving the public on January 9th, 2011. Because it is just slightly over a year old, the scope of data that we can use to observe the effects after implementation is very limited. Instead, we need to rely more on a cross sectional approach in an attempt to focus on extracting distance trends from the line.

Initially, we hoped to include commercial properties into the regression in order to determine different effects and extend the scope of our project. However, due to the limited number of observations with such land use codes, we did not have a sufficient amount to be able to draw any conclusions from the sample size. As a result, we focused only on residential properties for this analysis. It was expected that various types of properties would be included in the residential study, including single and multi-family housing. To account for this, we include corresponding dummy variables to capture the effects from the different types of development. However, for many of the housing codes there were an insignificant number of observations as well as data error entries that caused us to leave many of them out. In the end, we used single family units as our base and also included mobile homes in the regression.

IIID. Defining Variables

The base model constitutes all of the factors that make up the sale price of a property in terms of physical amenities and location. Our dependent variable is the sale price. We take the log of this number to control for very large values. Also, using the log of the price makes it easier to determine effects using percentage increases/decreases. This will create a standardized measurement so we can look at relative trends instead of absolute values.

From the tax lot data, we analyzed many of the housing characteristics and included those that appeared to have a significant effect on the model at the 5% level. Number of bedrooms (no_bedrooms) proved to have a significant role in the model, although it showed a negative coefficient meaning that number of bedrooms seemed to decrease the value of a property. This seemed counter-intuitive at first, but it is reasoned that there is decreasing marginal utility of bedrooms. In order to account for this, we created an interactive variable which combines the number of bedrooms with the total base of square feet. This allows the size premium of the property to vary with the number of bedrooms. Other significant housing characteristics are included in Table A and the expected effect on the dependent variable.

There were two main spatial factors that were hypothesized to have an effect on property values within the area: being in Eugene and proximity to the University of Oregon. We included a dummy variable to indicate whether or not the property was in Eugene. Yet, this proved to be insignificant after we had separated the lines into two different regressions. Additionally, the University of Oregon was perceived to have an effect similar to a central business district in large cities. That is, properties in close proximity will have higher values, and there will be a decreasing bid-rent curve as distance is increased. We used Google Maps to generate a distance variable from observations to the University of Oregon. The variable was found to be significant and have a negative coefficient, reinforcing our original assumption of the University's effects on house value.

Property values are well known to fluctuate over time from general market trends. Due to this factor, we included dummy variables to signal the year in which the house was sold. As stated before, our range begins in 2002 and continues to 2012. Unsurprisingly, the coefficient values show increasing values up until the housing market crash in 2007 (Graph 3). This drop in value could potentially dilute some of the findings related to trends in the EmX effects since it was implemented in the same year that property values crash. However, the presence of these dummy variables should extract most of these effects and separate the market crash from the Franklin EmX presence.

Extending from the base model, we incorporate effects from both the Franklin and Gateway lines. Using Google Maps, we were able to calculate the minimum distance from each observation to the nearest EmX stop based on longitude/latitude coordinates. Google Maps has various ways to calculate the distance to a certain point. There are three modal choice options which are car, walking, or public transit. Given that the model is analyzing house values based on distances to bus stops, we examined walking distances as the only relative modal choice for EmX users. There are no park-and-ride stops on the EmX lines and using other public transit would be beyond the scope of this project. Further, this reinforces the decision to include a limited relevant distance range of house observations. After running the code, Google produces two different options to measure distance: time to walk, or total distance in miles. Since the miles are rounded off to only one decimal point, we found that this would yield less precise estimates than minutes. Google Maps uses a walking pace of 3mph and these values are used to estimate the minimum distance variable (mindistance) to the nearest EmX stop. For quantifying these time values into a physical distance measure, one needs to simply multiply these values by .05 to receive the distance in miles. So, a house that is 20 minutes away from an EmX stop is 1 mile out.

Due to limited data, we were not able to incorporate neighborhood characteristics that would affect the price of a certain property. Therefore, neighborhood amenities, demographics and density are summarized in proxy variables. An important inclusion in this model would be density of a given neighborhood; density changes the efficiency and therefore value of transit. As proxies, we incorporated dummy variables to indicate which stop was calculated as the closest option. These dummy variables give insight into the influence of the missing variables and control for omitted variable bias. Conversely, it may cause bias in the equation because it is not an ideal proxy. For each bus stop along the line, we designated a corresponding variable that takes the value of 1 if the observation has been paired with it. So, for example a stop closer to the downtown area may have a different effect than that of stops on the east end of town towards Springfield. Along with these spatial matches, we also interacted the distance to the University with minimum distance to a stop (uosuminteractive). This indicates a premium of having a bus stop that is close to the University of Oregon.

Finally, we created our main variable of interest. This is an interaction of the minimum distance with the presence of the EmX. Our data only measures the year of the sale and not the month. Fortunately, the implementation of both EmX lines occurred in January of the respective years. Since the Franklin line was put in place during the beginning of 2007, we have an interactive variable measuring the trend in minimum distance with all the years after 2006. Correspondingly, the Gateway measurement included any property that was sold after 2010. This variable was predicted to extract the true relationship between distance to the nearest BRT stop and property value.

IV. Results

When extending from our base model, we generated four models in order to analyze the data. First, we separated the two lines so that we may decipher trends individually. Then for each line, we regressed our data through a general interactive distance approach as well as a BIN model to attempt to uncover various distance effects depending on threshold areas. After observing the data, it appeared as though there was a general negative trend between residential housing prices and minimum distance along the Franklin corridor. This pattern can be particularly observed in the years following the implementation of the EmX line (Graph 1). Such a trend led us to believe that there would be an effect generated from the availability of bus rapid transit. The Gateway data seemed to display an opposing trend; housing prices seemed to slightly increase as minimum distance increased (Graph 2). This could be caused by a multitude of factors that could distort our estimates, but we explored the line nevertheless.

IVA. Franklin

BIN Model

The BIN model is a regression output that creates different threshold distances to extract trends across various distances. We created 6 different variables based off of the walk time (measured in minutes). The closest distance was used as the base dummy variable. Each threshold was separated into a ten-minute range. So the base distance was all observations within a ten-minute walk of the nearest EmX stop. Following this were observations within an 11 to 20 minute walk, then those within a 21 to 30 minute walk, etc. We continued these intervals up to a 60-minute walk. After running test regressions, it appeared that the data beyond this point was insignificant and rather erratic. We hypothesized that any trends that able to extract would be within this 60-minute walk. Each threshold was separated into two variables, one that included all the available years from 2001 and another that signaled whether or not the Franklin line was in place. Due to the inclusion of these threshold variables, we did not need to include any other factors to account for the distance effect.

After running the regression, we found a downward trend as distance was increased away from the nearest stop. However, many of the ranges proved to be insignificant. The only interactive threshold distance that was significant at the 5% level was the 11 to 20 minute distance. From this approach, we hoped to be able to closely analyze the distance effects and pull out different magnitudes depending on how close the observations were to an EmX stop. Yet, the coefficients did not seem to fit in the model at the 5% significance level, thus we could not rely on most of these estimates. As a result we decided to approach the Franklin line in a more general sense concerning the measurement of distance.

General Distance Approach

Through our general approach, we include all of the stop dummy variables along with the two interactive variables; one for indicating the presence of the EmX line and the other relating the distance to the University center. To test for the joint explanatory power of the year dummy variables, interactive variables and distance variables we ran an F-test. These proved to be significant at the 5% level. Using the general base model as our restricted model, the F-test returned a value of 10.18, establishing the significance of our additional variables.

Through the specification of the model, we originally hypothesized that the function would include nonlinear trends in regards to the distance variables. This was not the case, as the inclusion of squared distance variables proved to be insignificant. We also created a minimum distance variable of 1/minimum distance to apply to the model in order to try and account for diminishing effects as distance is increased. Again, this ended up being insignificant when applied to the model. As a result, we based our model upon a linear regression.

In the linear regression, which we will call the Non-Control Group Model, the stop variables took a wide range of coefficient values. These values indicate the effect of general location on the property. They range from high positive values to low negative values, showing that the spatial area does seem to have a varying effect. Of the variables that did not end up being significant, many were in the Springfield area or were a two-way stop. Two-way stops are the EmX stops that have a separate inbound/outbound station. The high correlation between two-way stops suggests an explanation for why one of the pair may read as insignificant.

The minimum distance variable shows an arbitrary trend to the location of where an EmX should be. This incorporates the time before the implementation of the EmX stations so it is used mainly for comparison purposes. This can be viewed as a variable that measures distance to the Franklin road, independent of whether or not the EMX is present. We find a positive coefficient indicating that as we move away from the hypothetical stop location, property values seem to be going on an upward trend. This could be due to unwillingness to be near busy roads. High volume of traffic on Franklin creates a much noisier, less private place to live that could explain the devaluation of properties near the road. As stated before, the interactive Franklin EmX variable measures the same thing, except it only takes the observation into account if there is an EmX station present at the location. This time, we find a coefficient of -0.0018308. This means that for every walking-minute that separates a property from an EmX station, there is a premium of approximately .18%. Or, for every walking-minute moving out along observations, sales prices are estimated to decrease by .18%. These results use heteroskedastic-robust standard errors and are listed with the respective regression coefficients in Table A.

Our initial regression excluded observations that were outside a 60-minute walk from the closest EmX stop. To extend from this model we included those outside this initial distance and call this a Control Group Model. Those beyond the 60 minute radius would not be associated with a stop and therefore have no impact on our distance variables. They simply act as a control for comparison purposes in order to draw out more effects related to other variables. After running this model, we found a more conservative coefficient estimate for the franklin EmX variable; -.0011 or a .11% premium per walking-minute that can be applied to houses within a 60-minute walk of an EmX stop. (See Table C). The smaller absolute value of this number means that the model applied a greater emphasis on the other variables within the model. Due to the significant results and higher R squared we decided to keep this model for further analysis.

Often in cross-sectional, it is necessary to test for heteroskedasticity. We did this using White's Test. Initially, we tested using a Lagrange Multiplier Test but the correction altered the R squared significantly and was therefore not useful. As is commonly found in hedonic housing price models, the initial results are affected by heteroskedasticity. This violates the assumptions under classical linear regression models known as the constant variance assumption or homoscedasticity. It states that the variance of the error is constant across all observations. For example, heteroskedasticity will be present if the variance of the unobserved factors affecting home values increases or decreases with multiple independent variables in the model. The problem of heteroskedasticity does not bias the regression coefficients, but it does affect the standard errors. When the standard errors are affected, it is possible that a coefficient appears statistically significant when it is not.

Autocorrelation violates the assumption that the covariance of the disturbance term is independent. Serial autocorrelation is explained through the year dummy variables in our analysis. It controls for influence on variables due to the year and succession of years. Spatial autocorrelation occurs when variables near each other are likely to affect each other. In this case they are likely to be similar to each other; it is positive spatial autocorrelation (Dougherty). Spatial autocorrelation is addressed in our analysis through the dummy variables for the nearest EmX stop, controlling for neighborhood characteristics. It takes into account the effects of proximity and general issues. We recommend that further investigations consider testing for spatial autocorrelation.

Multicollinearity is the correlation between two explanatory variables. Due to the fact that some of the variables in our model are a function of an interaction from another explanatory variable causes multicollinearity. This does not bias the equation or cause invalid standard errors (Dougherty). Further, such a large sample size controls for linearity issues.

To further examine the results, we created a dummy variable indicating whether or not properties sold for greater than the median value in order to address different effects across varying home values. This dummy was interacted with the interactive Franklin EmX distance variable, the effect of distance and the EmX regarding homes valued greater than the median sale price. This variable was applied in both the Non-Control Group Model and Control Group Model. In both cases, the median price interaction variable was significant and relatively more negative than in the first regression. For the Non-Control Group Model a -.19% effect and for the Control Group a -.17% effect (See Tables D and E respectively). This result indicates that the higher the sale price of house, the more the benefits of the EmX will be capitalized into that value.

IVB. Gateway

We approached the Gateway model in a similar fashion as the Franklin. In both models, we separated the two by only including observations that were associated with the corresponding stops. Due to the time frame of the Gateway implementation, we were only able to look at data for one year after the line was in effect. This limited the scope of our research on the effects in the area.

BIN Model

As with the Franklin line, we created threshold distances to measure out effects across locations. The model is specified exactly the same, except it uses the Gateway stop dummy variables and draws from the observations that are linked to these stops. After this regression, we received several significant t statistics for the non-interactive distance variables. However, there did not seem to be a consistent pattern to draw from. There is neither an increasing nor decreasing trend of housing prices as we move along different distances. Once again, the interactive BIN distance variables did not prove to be significant. Thus, the model would be unreliable to draw any conclusions.

General Distance Approach

Again, this model is parallel with the Franklin approach except for the inclusion of respective dummy variables and observations. We include the minimum distance variable again and focus on an interactive term to indicate the effects on distance to the presence of the Gateway line. We find a handful of stop dummy variables that are significant to the model. Yet, many of these coefficients are negative. It is possible that this is indicating the premium of being along the Franklin line. This could be capturing neighborhood characteristics that are different from those in our other model. Intuitively this makes sense, as there could be a larger premium to be situated near the Eugene downtown and the University of Oregon.

From our distance variables, we observed a negative coefficient on the general minimum distance. This indicated that there was a downward trend as distance increased from the stops. Yet, our term accounting for the presence of the Gateway EmX proved to be insignificant this time. Even when the general minimum distance variable is taken out of the regression, the interactive term still displays an insignificant result. This could very well be an indication that there simply has not been enough time since the implementation of the Gateway EmX line for the value to be capitalized. It is difficult to judge the lag time for these effects to be asserted into residential sale prices. From these results, it would appear that a year is simply not enough time to be able to pick up aggregate trends among houses in the area.

IVC. Aggregate Estimates

After analyzing the trend in the Franklin area, we analyzed an aggregate estimate of the total value added from the implementation of the EmX line. This was achieved through taking into account homes that are within a 60 minute walk of the nearest stop. We decided to use this as our limit because this regression produced the highest r squared and seemed to produce the greatest significance with our distance variable. After extending different models beyond this 60 minute radius, the data became rather erratic. So, to keep consistent with our principle model, we used the homes 3 miles away (or 60 minute walk) as a base estimate. We then applied our .18% premium for each observation closer (.11% for the control group) and derived a total estimate of the value added from this line.

The result was a total value of $24,529,049 added to residential homes in the area from the non-control group and $14,918,667 for the control group. These numbers are fairly high and most likely due to our generalization of trends and possible overestimation of the effects from the line. We assume that property values assume the value added immediately after the EMX line is put into place. Throughout our model, we take into account observations for all of 2007 when in reality, properties may realize the benefit of EMX presence in 2008 or even later. This time lag cannot be determined from the scope of this project and may cause estimates to not be as efficient. We also assume that all values take on the same trend and extend to a radius of a 60-minute walk. From earlier, the linear regression appeared to derive the best fit but the extent of the distance cannot be precisely determined. We hypothesize that the effect of the EMX is less than a 60-minute walk and so our overestimation may add more onto the aggregate value. By using this distance and linear value, homes directly next to a stop would take on a value 10.2% higher (due solely from the EMX impacts) than those 60 minutes away. This is not unreasonable as a previous case study done in Pittsburgh found that residential properties near a BRT stop displayed premiums of up to 10%. We also ran into the problem of double entries for certain properties. If a lot was sold multiple times in our time period, our regression would count these as different entries and add them up separately. Yet, our estimates are also derived from sale prices and not assessed values. So, there are a large number of homes that are not included in our data set which would be positively affected by the EmX. Hypothetically this underestimation would balance out some of the overestimation due to multiple entries for single properties. All of this is not to say that from these wide assumptions we cannot determine a range for the total value added to properties in the area. In order to account for these factors that may produce high estimates we also generated values for the lower bounds of our 95% confidence intervals as can be seen in Table E.

Comparative to the cost of the EmX implementation, no estimate exceeds the monetary cost of the EmX implementation, but the non-control group approach comes closest. The Franklin line had a total cost of approximately $25 million dollars, about $6.25 million per mile (Table E). BRT lines provide a number of benefits to the community. In this study, we examine the effect such benefits offer in terms of sale prices for residential homes. Our estimates show that the values of homes sold appears to be close to the cost of the EmX line. Though, one crucial factor to consider is that our aggregate estimates are only based upon sale value and not assessed value of properties. Since many properties did not sell in these years, we can assume that there is an even greater value added to homes in the area. Further, our approach does not take into account commercial properties. Estimates using assessed/commercial value would be useful to make these predictions, but it is likely from the present trends that the overall benefit added to the community would exceed the cost of the Franklin EmX line if such values were calculated.

V. Conclusions

In real estate, amenities in an area add value to homes. The added value of amenities can be determined as they are capitalized into home value through utilizing hedonic regression analysis. This study analyzed the value of implementing a bus rapid transit line, the EmX, in Eugene, Oregon.

The study attempted to quantify the value of both the Franklin and Gateway EmX line through house values. It uses tax lot data on houses and distance calculation to both EmX lines. It was found that after the EmX was implemented into the Franklin corridor, the housing prices decreased as the distance to the nearest EmX stop increased. For every walking minute that separates a property from an EmX station, there is a premium of approximately 0.18%-0.11% depending on the model. However, the results with Gateway were found to be insignificant. There was a large problem with lack of observations because the line was recently implemented in 2011. It is recommended that this be reexamined once sufficient time elapses for the value of properties to be realized. There may be upward bias resulting from autocorrelation and subsequent efforts should account for this.

Lane Transit District plans to implement another EmX extension in West Eugene. This study supports the hypothesis that an EmX line would positively affect property values. However, the extension includes many commercial properties. Therefore it is important that further studies address commercial as well as residential property value.

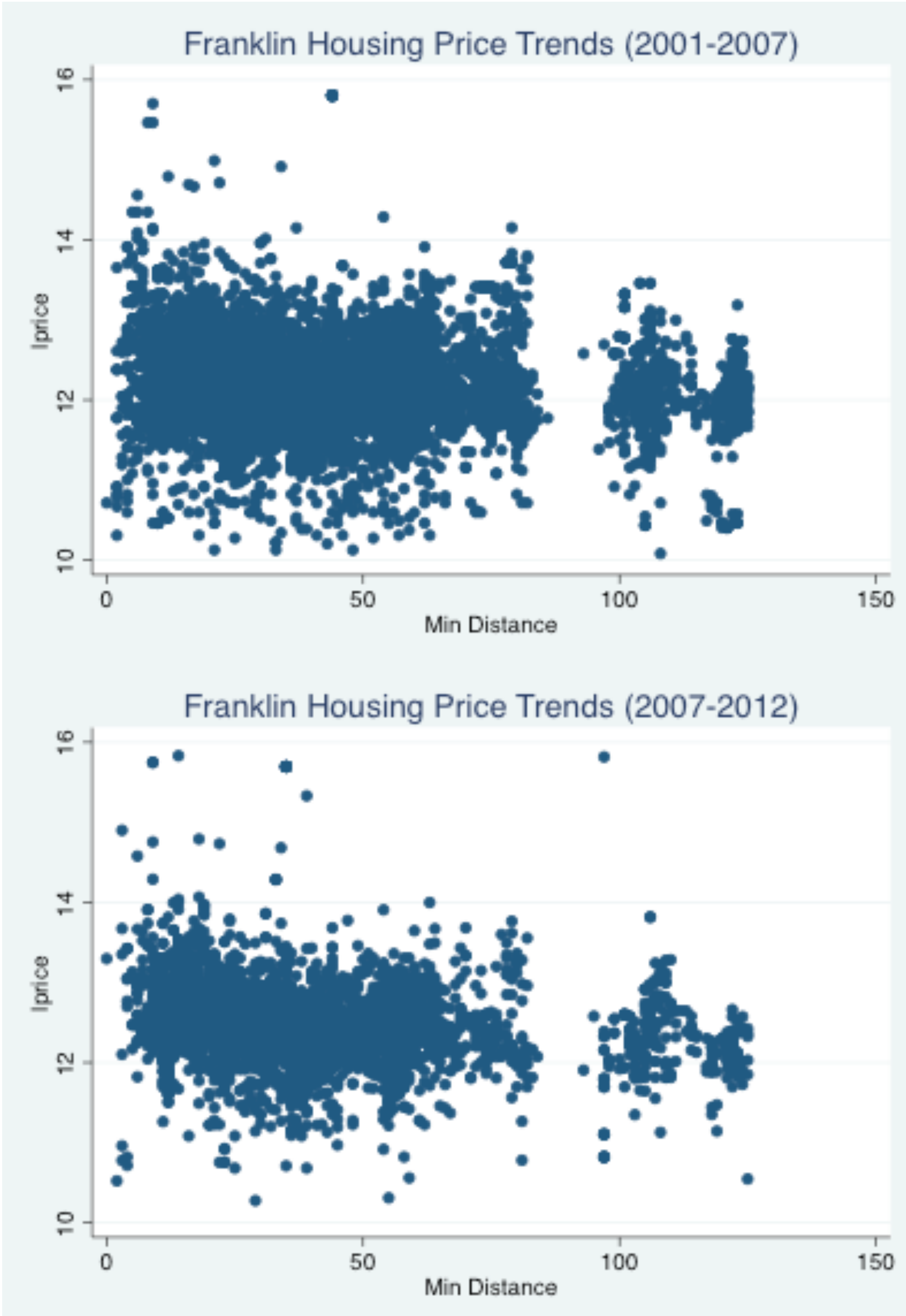
VI. Appendix

Table A: Variable Specification

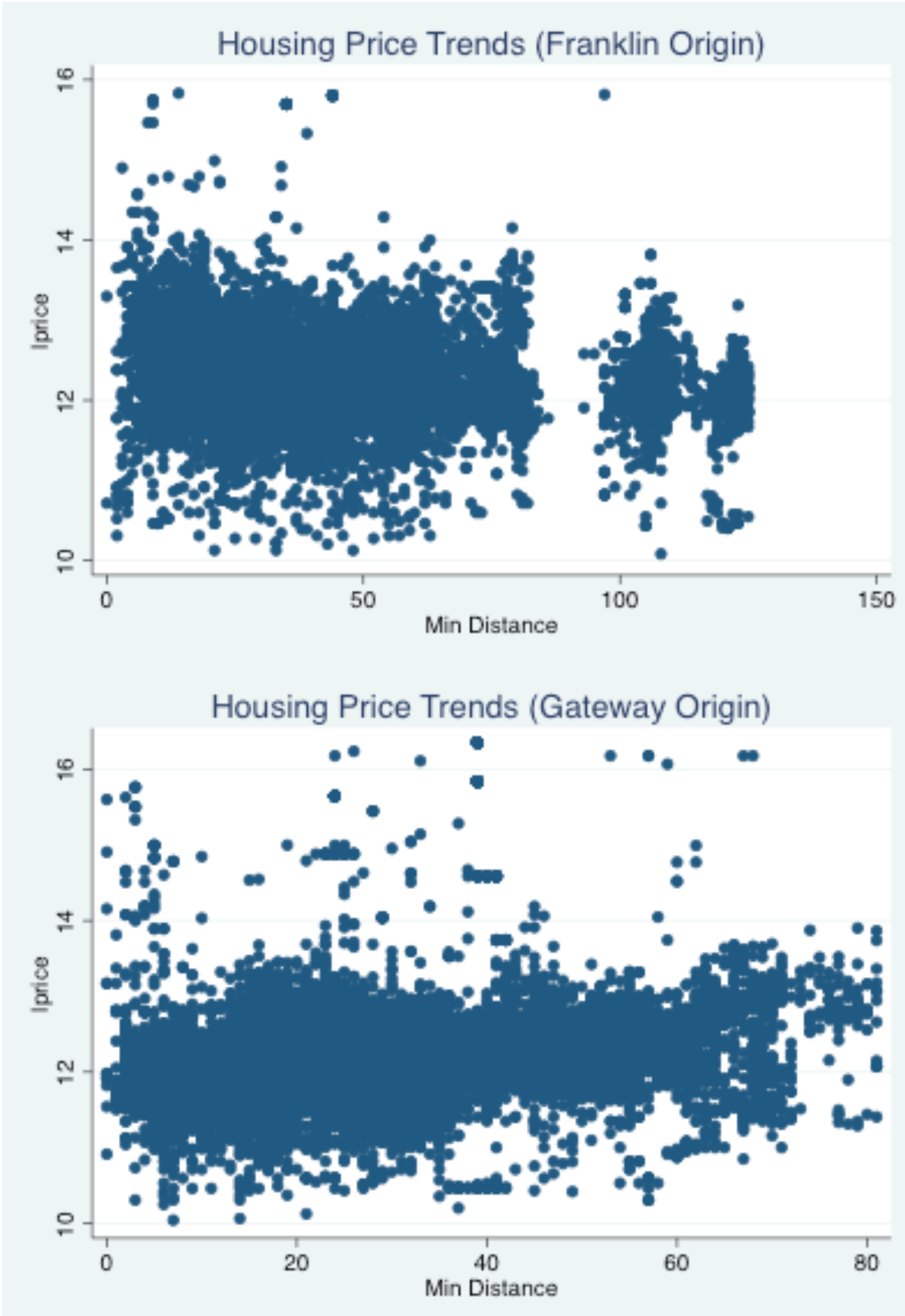
Variable	Variable Abbreviation	Expected Coefficient	Significant at 5% Level	Coefficient
Log of the sold price of house	lprice	Independent variable		
number of bedrooms	no_bedrooms	(-)		(-)
no_bedrooms*total_base_sqft	no_bedroomsinteractive	(+)	No	(+)
number of full bathrooms	no_fullbaths	(+)		(+)
number of half baths	no_halfbaths	(+)		(+)
year built	year_built	(+)		(+)
effective year built if majorly renovated	eff_year_built	(+)		(+)
attached garage square feet	attached_garsf	(+)		(+)
driveway square feet	driveway_sf	(+)	No	(-)
concrete patio square feet	concrete_patio_sf	(+)		(+)
total property square footage (confirm this)	total_base_sqft	(+)		(+)
percent complete of property	pct_complete	(+)		(+)
fireplace dummy	fireplace	(+)		(+)
forced air heating	heat_forcedair	Reference category		(+)
heating pump	heat_hpump			(-)
heating base	heat_base			(-)
gabled roof	roof_gable	Reference category		(+)
shingled roof	roof_shingle		No	(-)
cedar wood roof	roof_cedar_wood			(+)
dummy variable for land use code	luc_singlefamily	Reference category		(+)
dummy variable for land use code mobile homes	luc_mobilehome	(-)	No	(+)
dummy variable for properities in Eugene	eugene	(+)	No	(+)
dummy variable for eugene station	eugenestationdum			(+)
dummy variable for high stop	highdum			(-)
dummy variable for hilyard stop	hilyarddum		No	(-)
dummy variable for dads gate stop	dadsgatedum		No	(-)

dummy variable for walnut stop	walnutdum			(-)
dummy variable for franklin stop	frankindum		No	(-)
dummy variable for glen outbound stop	glenoutdum		No	(-)
dummy variable for glen inbound stop	glenindum		No	(-)
dummy variabel for lexington inbound stop	lexingtoninbounddum		No	(-)
dummy variable for lexington outbound stop	lexingtonoutbounddum		No	(-)
dummy variable for mcvay stop	mcvaydum		No	(+)
dummies for years 2003-2012 relative to 2002	y17-y27	(+)		(+)
minimum distance to nearest EmX stop	mindistance	(-)	No	
mindistance*dummy for years after 2007	interactivefranklinemx	(-)		(-)
distance to University of Oregon	uosum	(-)		(-)
uosum*mindistance	uosuminteractive	(-)		(+)

Graph 1: Franklin Price Trends



Graph 2: Gateway Price Trends



Graph 3: General Market Trends by Year

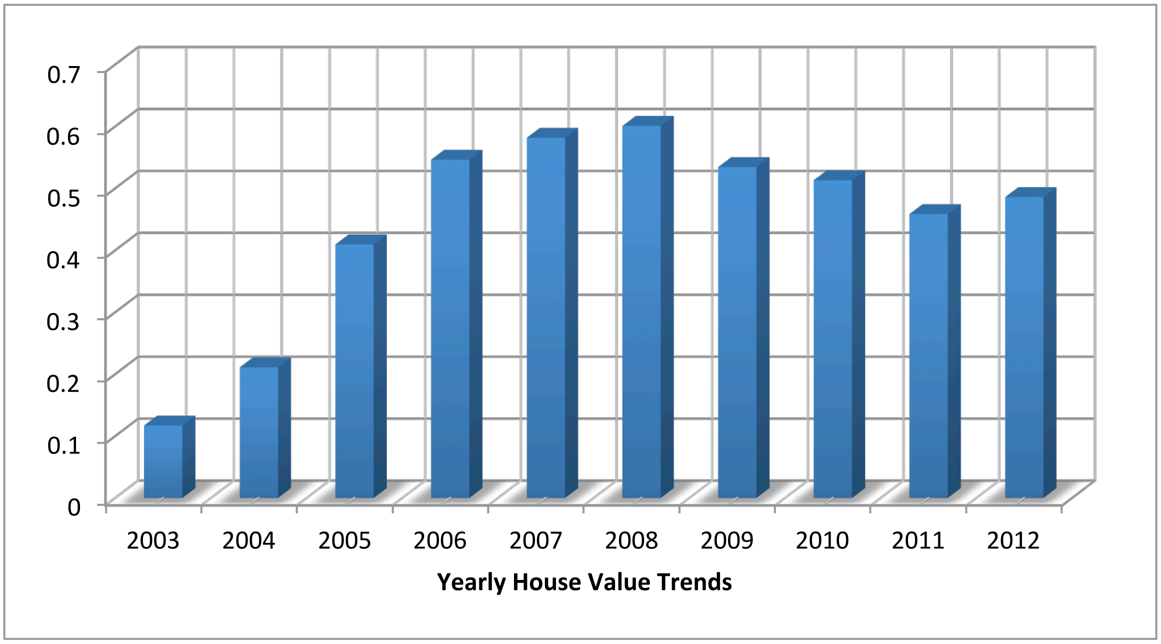


Table B: Non-Control Group Results

Non-control Group Model		Number of obs = 7170
**= Insignificant at 10%		F(43, 7126) = 286.89
* = Insignificant at 5% level		Prob > F = 0.0000
Dependent Variable: lprice		R-squared = 0.6057
		Root MSE = .3013
Variables	Coef.	Robust Std. Err.
no_bedrooms	-0.0073421	0.0023598
no_bedroomsinteractive	0.0038207	0.0114732**
no_fullbaths	0.077933	0.0085613
no_halfbaths	0.0466009	0.0091981
year_built	-0.0007429	0.0003292
eff_year_built	0.0016415	0.0002513
attached_garsf	0.0000988	0.0000189
driveway_sf	-3.72E-06	0.0000116**
concrete_patio_sf	0.0000599	0.0000166
total_base_sqft	0.0002261	8.60E-06
pct_complete	0.0149127	0.0026808
fireplace	0.048468	0.0068382
heat_hpump	-0.072382	0.0189081
heat_base	-0.0646186	0.0103873
roof_shingle	-0.0270023	0.0140819*
roof_cedar_wood	0.0984994	0.0149646
highdum	0.1241589	0.0225652
hilyarddum	-0.0090985	0.0194439**
dadsgatedum	0.0204342	0.0210561**
walnutdum	0.0529435	0.0257624
franklindum	0.0398935	0.0230498*
glenindum	0.0031309	0.0349266**
glenoutdum	-0.0756604	0.1051155**
lexingtoninbounddum	-0.0557063	0.1654029**
lexingtonoutbounddum	-0.1988858	0.1504248**
mcvaydum	-0.0321254	0.1584101**
luc_mobilehome	-0.1730701	0.3336048**
mindistance	0.0030234	0.0016273*
interactivefranklinemx	-0.0018308	0.0005649
eugene	0.0106008	0.1642294**
y17	0.1326745	0.0144593
y18	0.1963272	0.0137837

y19	0.3922533	0.0133573
y20	0.5237046	0.0133621
y21	0.5792658	0.0121919
y22	0.6227271	0.0237176
y23	0.5559842	0.0238144
y24	0.502723	0.0252768
y25	0.467665	0.0260467
y26	0.4711026	0.0373847
y27	0	(omitted)
uosum	-0.0165726	0.001516
uosuminteractive	0.0001103	0.0000194
_cons	8.527157	0.7184058

Table C: Control Group Results

Control Group Model		Number of obs = 8918
**= Insignificant at 10%		F(43, 8874) = 275.48
* = Insignificant at 5% level		Prob > F = 0.0000
Dependent Variable: lprice		R-squared = 0.5439
		Root MSE = .33229
Variables	Coef.	Robust Std. Err.
no_bedrooms	-0.00556	0.0017685
no_bedroomsinteractive	0.005267	0.0057609**
no_fullbaths	0.072416	0.008769
no_halfbaths	0.033852	0.0089478
year_built	-0.0013	0.0002899
eff_year_built	0.001962	0.0002453
attached_garsf	0.0001	0.0000192
driveway_sf	-9.85E-06	0.0000101**
concrete_patio_sf	8.81E-05	0.0000172
total_base_sqft	0.00022	8.71E-06
pct_complete	0.013867	0.0025685
fireplace	0.051849	0.00636
heat_hpump	-0.04239	0.0178828
heat_base	-0.07254	0.0104041
roof_shingle	-0.05022	0.0143124
roof_cedar_wood	0.088102	0.0148563
highdum	0.116275	0.022516

hilyarddum	-0.02002	0.0201975**
dadsgatedum	0.016979	0.0218087**
walnutdum	0.070341	0.025644
franklindum	0.035135	0.0236694**
glenindum	-0.01942	0.0346829**
glenoutdum	-0.05749	0.1056253**
lexingtoninbounddum	-0.05235	0.167129**
lexingtonoutbounddum	-0.18548	0.1503851**
mcvaydum	-0.05009	0.1582078**
luc_mobilehome	-0.1275	0.2088205**
mindistance	0.008094	0.0013763
interactivefranklinemx	-0.00113	0.0003114
eugene	0.028005	0.1638577**
y17	0.101698	0.0143744
y18	0.177576	0.0137349
y19	0.356413	0.0134228
y20	0.492476	0.0138393
y21	0.566747	0.0124559
y22	0.577511	0.0176276
y23	0.517291	0.0192144
y24	0.459494	0.0199426
y25	0.426911	0.0206841
y26	0.419259	0.0330111
y27	0	(omitted)
uosum	-0.01286	0.0013202
uosuminteractive	2.08E-05	4.55E-06
_cons	8.961337	0.6603577

Table D: Non-Control Group-Median Threshold

Non-Control Group-Median Threshold		Number of obs = 7170
**=Insignificant at 10% level		F(44, 7125) = 536.71
*= Insignificant at 5% level		Prob > F = 0.0000
Dependent Variable: lprice		R-squared = 0.7263
		Root MSE = .25101
Variable	Coef.	Robust Std. Err.

no_bedrooms	-0.0073942	0.0018905
no_bedroomsinteractive	0.0049001	0.0089007**
no_fullbaths	0.0343533	0.0067869
no_halfbaths	0.0244569	0.0075038
year_built	-0.0007928	0.0002667
eff_year_built	0.0008626	0.0002169
attached_garsf	0.0000716	0.0000152
driveway_sf	8.28E-06	0.00000975**
concrete_patio_sf	0.0000457	0.000014
total_base_sqft	0.0001388	7.49E-06
pct_complete	0.0109359	0.0022117
fireplace	0.0396999	0.0057327
heat_hpump	-0.058155	0.0147456
heat_base	-0.0395772	0.0087648
roof_shingle	-0.0207989	0.0111937*
roof_cedar_wood	0.0445848	0.0121932
highdum	0.1022792	0.0177804
hilyarddum	-0.0158532	0.01582478**
dadsgatedum	0.0011008	0.0172675**
walnutdum	0.0332946	0.0205985**
franklindum	0.009148	0.0191258**
glenindum	-0.0317306	0.02767818**
glenoutdum	-0.0075416	0.078148**
lexingtoninbounddum	-0.107204	0.1742738*8
lexingtonoutbounddum	-0.1882746	0.1434486**
mcvaydum	-0.0402304	0.1570987**
luc_mobilehome	-0.2232187	0.2986778**
mindistance	0.0053017	0.0013418
medianprice	0.4767407	0.011492
interactivemedian	-0.0019204	0.0003114
eugene	0.0214271	0.1567494**
y17	0.0908862	0.0120303
y18	0.1274543	0.0118803
y19	0.2472846	0.0116719
y20	0.3007055	0.0126552
y21	0.3414306	0.0117331
y22	0.3773618	0.0131496
y23	0.3335834	0.0142781
y24	0.2982054	0.0144908
y25	0.2905719	0.0151089
y26	0.2316374	0.0238847

y27	0	(omitted)
uosum	-0.0114141	0.0012495
uosuminteractive	0.0000453	0.0000161
_cons	10.52377	0.6064987

Table E: Control Group-Median Threshold

Control Group-Median Threshold		Number of obs = 8918
**=Insignificant at 10% level		F(44, 8873) = 587.78
*=Insignificant at 5% level		Prob > F = 0.0000
Dependent Variable: lprice		R-squared = 0.6950
		Root MSE = .27173
lprice	Coef.	Robust Std. Err.
no_bedrooms	-0.005338	0.0015123
no_bedroomsinteractive	0.0020701	0.0035501**
no_fullbaths	0.0291472	0.0068067
no_halfbaths	0.0168344	0.0073619
year_built	-0.0012018	0.000233
eff_year_built	0.0008543	0.0002081
attached_garsf	0.0000865	0.000015
driveway_sf	0.00000151	0.0000079**
concrete_patio_sf	0.0000618	0.0000138
total_base_sqft	0.0001231	0.00000735
pct_complete	0.0096366	0.0020883
fireplace	0.0392873	0.0052925
heat_hpump	-0.0351686	0.0135702
heat_base	-0.0428062	0.0088809
roof_shingle	-0.0320047	0.0110531
roof_cedar_wood	0.0279816	0.0118645
highdum	0.0849917	0.0174382
hilyarddum	-0.0160006	0.0162831**
dadsgatedum	0.003926	0.0177493**
walnutdum	0.0432223	0.020257
franklindum	0.011362	0.0195462**
glenindum	-0.0480933	0.0270621*
glenoutdum	0.0112938	0.0755166**
lexingtoninbounddum	-0.1101735	0.1781043**
lexingtonoutbounddum	-0.182942	0.1429857**

mcvaydum	-0.0396651	0.1571405**
luc_mobilehome	-0.2554803	0.1700572**
mindistance	0.007268	0.0011067
medianprice	0.5360461	0.0111104
interactivemedian	-0.0017524	0.0002431
eugene	0.0370705	0.1569703**
y17	0.0671256	0.0120223
y18	0.1137807	0.0113716
y19	0.2137653	0.0115086
y20	0.2664616	0.012631
y21	0.313719	0.011891
y22	0.3395885	0.0127881
y23	0.3034502	0.0130048
y24	0.2682241	0.0133223
y25	0.2604608	0.0138085
y26	0.1934238	0.02305
y27	0	(omitted)
uosum	-0.0087016	0.0010758
uosuminteractive	0.00000612	0.00000392**
_cons	11.38545	0.5504813

Table F: Summary Statistics

Summary of Statistics, Franklin Variables					
Variable	Observations	Mean	Standard Deviation	Minimum Value	Maximum Value
lprice	9060	12.2626	0.5012798	10.08163	14.34614
sale_price	9060	239507	128836.9	23900	1700000
mindistance	9060	43.8859	26.00293	0	125
interactivefranklinemx	9060	9.79183	21.46365	0	125
uosum	9060	57.7468	29.23757	10	146
uosuminteractive	9060	3275.2	3797.967	0	18250

Table G: Cost Benefit Analysis

Method	Non-Control Group	Non-Control Group-Lower Bound	Control Group	Control Group-Lower Bound
Benefit	24, 529,049	9,693,449	14, 918,667	6,747,230
Cost	25,000,000	25,000,000	25,000,000	25,000,000
Net Benefit	-470,951	-15,306,551	-10,081,333	-18,252,770

Image A: Franklin/Gateway EMX Line

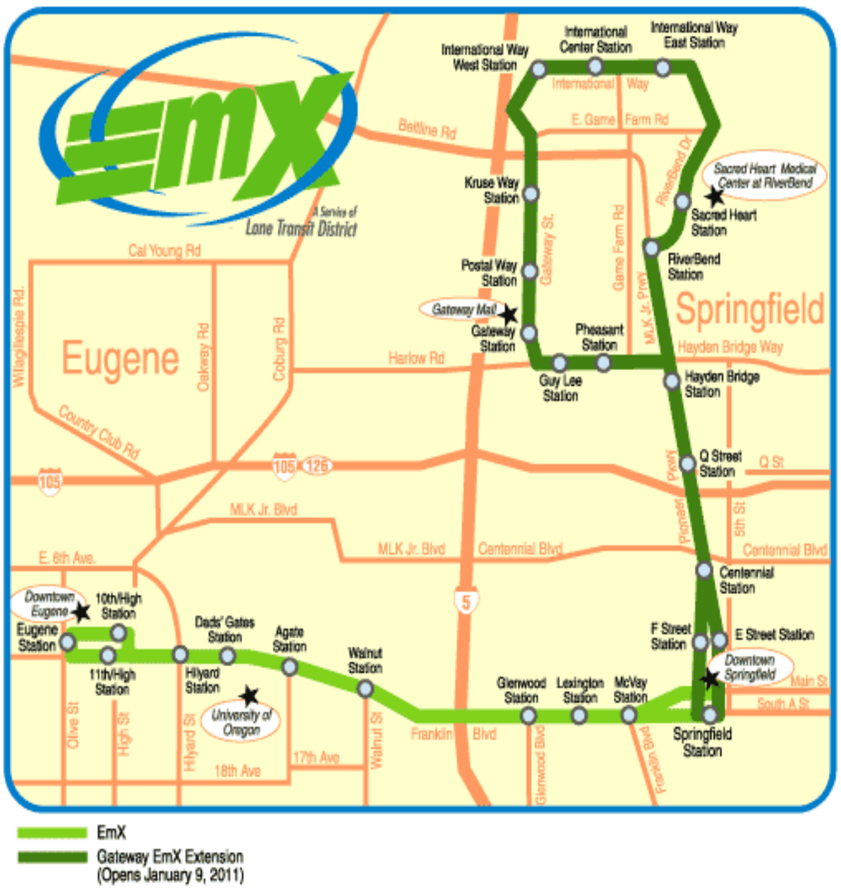
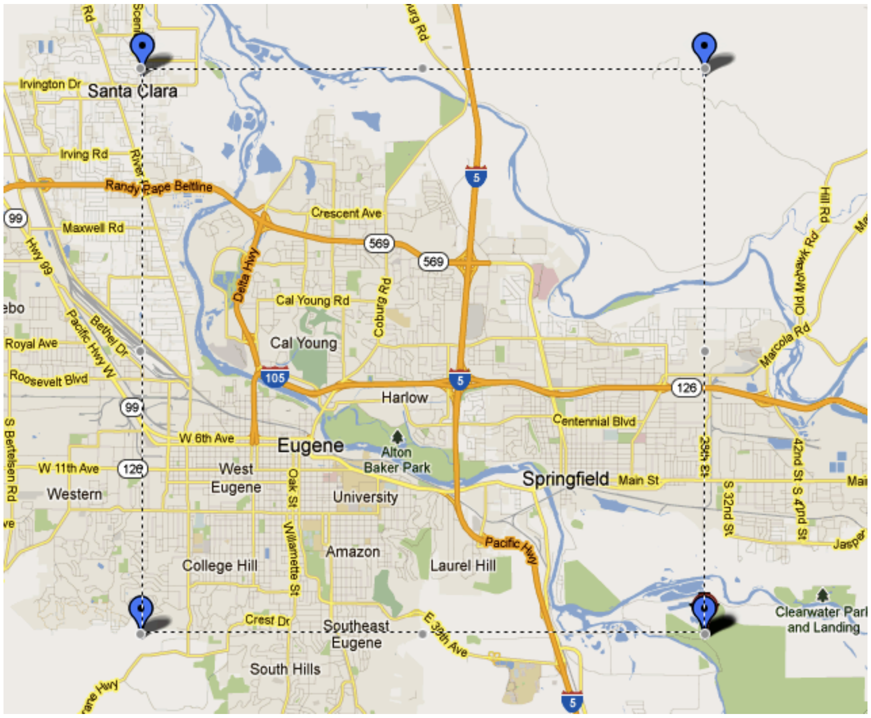


Image B: Range of Interest



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