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THE CONDITIONAL NATURE OF RAIL TRANSIT CAPITALIZATION IN SAN DIEGO, CALIFORNIA

By

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Abstract

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This dissertation will provide a detailed quantitative analysis of the effect that rail transit stations have on housing property values in San Diego, CA. Past research has shown that property near rail stations sells at a modest premium in many US cities. The new research presented here will build on previous work by looking at the conditional nature of rail transit capitalization. In other words, the findings from this research go beyond simply answering whether rail transit capitalization occurs but also illustrate that the capitalization benefits vary depending on a property's attributes and location within a region. This research will make use of hedonic price models with interaction terms to statistically determine how the characteristics of a location and property condition rail capitalization. More specifically, the models will test whether various elements or transit-oriented development (TOD) enhance capitalization benefits. The results of these models show that the higher density housing, permissive zoning regulations, a pedestrian-oriented built environment, and higher quality transit service can greatly increase the size of the premiums associated with rail proximity. This suggests a fairly strong market for TOD in San Diego. The findings also provide

evidence that the development impacts of rail transit investment depend on station location, system design, and complementary land use policy.

DEDICATION

This dissertation is dedicated to Karen. Her efforts allowed me the time I needed to complete this project.

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Chapter 1. Introduction

This dissertation will present a detailed analysis of how proximity to rail stations affects home prices in San Diego, CA. Property values have proved a sensitive index for analyzing the effect of many types of planning interventions (Knaap 1998). Assuming a reasonably open and competitive real estate market, the benefits provided by a localized public service or amenity should be "capitalized" into the sales prices of nearby properties. Investment in a transit system presents an excellent example of a planning intervention where property values can help in assessing the benefits of the intervention. To the degree that the transit investment provides increased accessibility benefits to a sufficient segment of the population, property values around transit stops/stations should increase. Many studies in recent years have sought to isolate and quantify the capitalization benefits of proximity to rail transit stations in US cities (Ryan 1999, Huang 1996). Chapter 2 will review this literature in more detail.

The large number of transit capitalization studies coincides with a renewed focus in the latter part of the 20th century on building rail transit systems (Kahn 2007). Rail systems had largely been abandoned in the first half of the century as the convenience, speed, and flexibility of the private automobile pulled people away from public transit (Muller 1995). However, as auto ownership became nearly ubiquitous and the vehicle miles traveled (VMT) greatly increased, many negative aspects of auto dependence became apparent (Murphy & Dellucchi 1998). Some of the more prominently discussed problems associated with an auto-based transport system include:

- *Congestion* – Auto usage has increased and will continue to increase faster than new road capacity in most large regions, creating congestion and, in the worst cases, gridlock (Downs 2004). Congestion is not necessarily a bad thing. A strong economy requires movement of many people and goods, which can result in congestion. Nonetheless, congestion does come with costs (MacKenzie et al. 1992). Individuals and certain kinds of businesses (e.g., delivery services) waste valuable time in traffic that they could use for more productive activities. Further, idling vehicles do not use fuel efficiently. Congestion directly affects a large number of people as well as the business community, making it the most prominent and widely shared concern related to the continued increase in auto use. Many surveys show that citizens rank congestion as one of the biggest problems facing their city or region (Black 1995, Ch. 1).
- *Emissions* – As usage increased, automobiles also became a significant source of air pollution and greenhouse gasses. The link between auto emissions and respiratory illness, cancer, low crop yields, and global warming has been well chronicled (Walsh 1999, Stutz 1995).
- *Energy Consumption* – The internal combustion engine presents problems because it relies on non-renewable petroleum fuel, largely imported from unstable parts of the world (Aten & Hewings 1995). Some argue that the US spends a large amount of money (through military spending) and political capital to protect international oil interests.
- *Sprawl* – The automobile combined with modern freeways provides fast and easy access to cheap land on the urban fringe. As land becomes cheaper, developers

respond by using more land per square foot of building space (O'Sullivan 1996, Ch. 8). In addition, the parking spaces and road facilities needed to support autos also require substantial tracts of land. Because of this extensive land consumption, the auto-oriented landscape poses a threat to pristine wilderness, wildlife habitat, farmland, and open space in general (Burchell et al. 1998, Ch. 5). This spread out land use pattern can also lead to longer trips and, thus, increased emissions and more energy consumption[1] (Burchell et al. 1998, Ch. 4). Sprawl can also make provision of municipal services and infrastructure (e.g., electricity, water, roads, and police) costly and difficult, although much the same might be said for dense areas with multistory buildings (Burchell et al. 1998, Ch. 3). It should be noted that some researchers believe that the benefits of sprawl, such as the availability of relatively affordable but large single-family homes and a wide array of location choices, outweigh the costs (Gordon & Richardson 1997). Comparing these costs and benefits requires a large degree of subjectivity, as the inherent value of wilderness and open space or a safe suburban home is hard to quantify.

- *Inequity* **–** Despite the increasing reliance on private automobiles, some people simply cannot drive. The elderly and disabled often have physical limitations that prevent them from safely driving a car, while many of the poor don't drive because they cannot afford a car. Focusing the transportation system on the automobile can cause great hardships for these disadvantaged population segments (Hine & Mitchell, 2001).

[1] Some argue that the decentralization of jobs and commercial activity brings homes and destinations closer together and limits increases in VMT.

Given the problems described above, many planners and policy makers have again focused on rail transit investment as key component[2] of a more “sustainable” transportation system. Rail can provide an attractive way to avoid congestion. If trains have a sufficient number of riders, they generate fewer emissions and less energy use per capita. Rail investment also can theoretically help concentrate development in walkable nodes around stations. This kind of development is often referred to as transit-oriented development (TOD) (Cervero et al. 2002). When rail investment is combined with TOD, the ability to redress the problems with the automobile are enhanced because it not only provides people with easy access to rail but it also makes it possible to meet many travel needs as a pedestrian. Proponents of rail have long justified the heavy capital costs with the prospects for such land use impacts (Knight & Trygg 1977). Capitalization studies provide a way to evaluate the degree to which rail investment can actually confer the desired benefits.

Generally speaking, the value of these transit capitalization studies lies in the fact that they express the benefits of a rail transit system as an easily understandable monetized value[3] (e.g., properties near a station are worth $5,000 more than an otherwise similar property not near a station). Beyond the simple exposition of a

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[2] Rail investment can only be considered one component in addressing the problems with automobile use. There may be better ways than building rail systems to redress the problems with auto use. For example, congestion pricing more directly solves the congestion problem, more fuel efficient vehicles might have a more realistic impact on emissions and energy usage, and land use regulation could more directly limit sprawl. Such strategies (along with many others) could likely be used in concert with rail investment to most effectively reduce the negative impacts of auto use.

[3] Estimating capitalization benefits is not the most direct way to measure the benefits of a transportation investment. Calculating the aggregate reduction of travel time/cost for all users of a transportation network provides the most direct measure (Bannister & Berechman 2000). However, doing so requires assigning an arbitrary monetary estimate of the value of time (in reality, the value of time differs for each individual) and can be more data intensive and complicated than measuring capitalization benefits.

monetary benefit, the premium value also serves as an indicator as to the possibility of development impacts and the potential for value capture.

The premium value provides a good indication about the potential for rail investment to stimulate and focus development around stations. If a rail station increases the value of surrounding properties, it illustrates an attractiveness that, given available land, will likely draw new development. Higher property values can also result in higher density development (assuming land use regulations permit higher density). Developers should theoretically respond to increasing land values by minimizing the amount of land per square foot of floor space (O' Sullivan 1996, Ch. 8). Additionally, if existing development becomes incongruent with the increasing land value, higher density redevelopment can be expected.

Monetized capitalization benefits also indicate the potential for value capture. A value capture scheme taxes properties around stations to recoup some of the value provided to a parcel by station proximity (Smith & Gihring 2006). Large capitalization benefits would indicate the potential to tap into large source of extra revenue. This extra source of revenue might allow transit operators to lower fares, expand service, become less dependent on subsidies, and less beholden to political interests.

This dissertation will expand upon the previous transit capitalization research by looking at the conditional nature of the capitalization benefits. The findings will go beyond simply answering whether rail transit capitalization occurs in a given region. Instead, the research is designed to reveal how synergies with certain attributes of a location and/or a property can condition the value of rail proximity. Thus, the potential policy implications revolve around using the findings to inform land use planning around stations, pick the most viable station locations, and design a rail system that will maximize the value of a rail investment.

It should be noted that, even if good planning can maximize the benefits of rail investment (whether through the lessons of this research or otherwise), the heavy capital costs may still outweigh the benefits. Not every region has the population and/or employment density to support rail investment (Pushkarev and Zupan 1977) and some vociferously argue that rail is always a bad investment (O'Toole 2001, Rubin et al. 1999). Nonetheless, decisions about public investments are made in a political arena that may ignore and even distort objective analysis of costs and benefits (Wachs 1995, Pickrell 1992). This has and will lead to the funding and construction of rail projects where benefits do not justify the costs. However, even "bad" (in terms of costs and benefits) projects can still improve through good planning, whether in the early planning stages or after the system has been designed and constructed. Even though this research is not designed to determine whether San Diego's rail system was a prudent investment[4], the findings will hopefully provide useful information in maximizing the returns on rail investment (in San Diego and more generally).

[4] While this research does not explicitly compare costs and benefits, this does not mean that such analysis is not necessary or valuable, even if done ex-post facto. Rather, it simply goes beyond the scope of this analysis.

Chapter 2. Theory and Empirical Literature

2.1 Location Theory

The hypothesis that proximity to transit can raise property values relies upon the theoretical framework provided by urban economics and, more specifically, location theory. Location theory asserts that good accessibility results in higher property values (Alonso 1964). A highly accessible location provides travel cost reductions[5] and, therefore, such a property will draw higher bids than a less accessible but otherwise identical property. In a competitive land market, the bids will theoretically rise until the cost savings provided by the location are fully capitalized into the price of the property.

Things become complicated when considering that, for each household or firm, the level of accessibility and the corresponding cost savings provided by a given location will vary. Historically, most of a city's jobs and services were located in a central business district (CBD) and, therefore, good access to the CBD meant cost savings to almost everyone. In modern cities, commercial activity has become dispersed (White 1999, Pivo, 1990). While access to the CBD still has value to many, decentralization has greatly muted this demand. The optimal location in terms of accessibility will vary from household to household depending on workplace location

[5] Generalized travel costs come not only from out of pocket expenses, such as fuel, tolls and fares, but also from travel time, stress, and other inconveniences associated with travel.

and where the household prefers to shop, recreate, and attend school. Firms will value good access to a labor pool, customer base, support services, and inputs and the best location for these things will depend highly upon the type of business.

Just as with any good or service in a free market, supply and demand will figure significantly in the property value at a given location. With regard to accessibility, the extensive transportation network found in most modern cities creates a fairly large supply of locations with at least an adequate[6] level of accessibility (Giuliano 1995). At the same time, because of decentralization and the diversity of accessibility needs (as previously discussed), no one location will generate a huge demand. The robust supply of accessible locations and limited demand for any particular location indicate that access will most often play a limited role in determining property values. However, most regions have some areas that provide uniquely high levels of accessibility: properties in and around large business districts, near freeway interchanges, and possibly near rail stations (Ryan 1999, McDonald & McMillen 1990). Such properties provide good access to many people and are in short enough supply that they should create the kind of competitive bidding needed to generate significant accessibility premiums. These locations become even more desirable in the face of rising congestion.

2.2 Transit and Location Theory

[6] What defines "adequate" accessibility is somewhat subjective but might be roughly defined as a location that does not inordinately burden the owner/tenant with travel costs. For example, having a one-way commute of more than an hour is probably less than adequate for most people.

One can legitimately question whether transit plays any role in creating the type of accessibility needed to influence property values. Transit only plays a minimal role in the transportation system in most US cities (Fielding 1995). There are a few dense and congested areas in the US (especially New York City) where proximity to transit stations still provides a clear accessibility advantage. The majority of regions have a more dispersed and auto-oriented development pattern (San Diego included) where the auto is the dominant mode. The pattern of increasing congestion will serve to make transit more competitive with auto in many places, especially in certain high demand corridors (Lewis & Williams 1999, Ch. 3). Nonetheless, for the foreseeable future, the auto will remain the fastest and most convenient option for the majority of travel scenarios. This limits the potential for transit to impact property values.

Despite the clear advantage of the automobile in most US regions, there may still exist segments of the population that value access to transit enough to pay a location premium. Certain socio-demographic characteristics make people theoretically more likely to value transit access (Black 1995, Ch. 12, Polzin et al. 2000):

- *People who work in downtown locations (and other large job centers)* will likely find transit attractive because it can provide competitive travel times in the congested corridors leading to major business districts. Additionally parking is often expensive in such areas, making transit a cost saving measure.
- *People who live in urban neighborhoods* might tend toward using transit because owning, operating, and parking a private vehicle is expensive and inconvenient in dense urban areas.

- *Small households (1 or 2 adults)* are more likely to have uncomplicated travel needs that transit can realistically meet.
- *The elderly and disabled* who cannot operate a private vehicle often rely on transit.
- *Low-income households*[7] may rely on transit because they cannot afford private transportation necessary to accommodate their travel needs.

Beyond demographics, certain attitudes and lifestyle choices also can lead to a preference for transit (Handy et al. 2005):

- *People with concerns about the environment* might favor transit to avoid the emissions and other negative environmental externalities associated with auto use.
- *People who are sensitive to stress* may favor transit[8] so they can avoid rush hour driving.
- *Those who value the ability to be productive (working or reading) while traveling* may prefer transit.
- *People who are frugal* might avoid the expense of auto use in favor of a potentially slower transit option.

Whereas demographic characteristics are readily available from census data, these attitude based groups are much harder to locate and enumerate. While they likely don't make up a large share of the populace, these groups likely form a key component of transit ridership.

[7] Low income households, for obvious reasons, can't contribute much to bidding up the price of station area properties. Similarly, low income households may get priced out of transit-oriented housing even though they may benefit most from it.

[8] People who are stress sensitive might also avoid transit because of crowded trains and busses and unreliable service.

The demand for station area property will largely depend upon a combination of the size of the transit-friendly population segments described above and the ability of rail to effectively compete with the auto in rail served corridors. If this demand is greater than the supply of property near stations, such property should sell at a premium. One reason to believe such premiums are possible is that, even in regions with an extensive rail network, the share of land within walking distance[9] of a station is extremely limited[10]. Therefore, the demand necessary to create premiums is small enough to be realistic. Empirical evidence from previous research on North American cities (discussed below) has found that property around rail stations usually does sell at modest premiums, indicating that the demand for such property likely exceeds supply by at least a small amount.

2.3 Hedonic Price Literature

Before undertaking a detailed analysis of the empirical evidence for transit capitalization, this section will provide a broader review of research that seeks to statistically define the determinants of property values. Myriad factors influence property values and, as a result, there exists a broad body of literature that examines the relationship between these various factors and property values. A hedonic price model most often provides the tool for such analysis. Hedonic price theory asserts that a commodity has multidimensional value that can be broken into component parts

[9] Walking distance is usually defined as being within ¼ or sometimes ½ mile of a station, which is roughly equivalent to a 5 or 10 minute walk.
[10] Rail systems with more stations likely provide greater accessibility. This will offset the dampening effect of greater supply.

(Rosen 1974, Bartik 1988). Thus, a hedonic price model uses multiple regression analysis to statistically isolate the implicit price of a commodity's various components. The effects of many factors on the price of property have been estimated using a hedonic price model.

Hedonic price analysis can be generally critiqued on a few major issues, usually stemming from the fact that such research usually makes use of cross-sectional data. First, in order to generate unbiased price estimates of a given property attribute, the model specification must effectively control for potentially confounding factors. For example, anything that potentially affects property values and is also correlated with rail proximity must be included in a model or the rail proximity coefficient will conflate the effect of this unobserved attribute with the actual value of rail. Even if a model has a rich set of controls, unobserved factors[11] may still bias the coefficients (Kennedy 2003, Ch. 17). The other main weakness of cross-sectional hedonic price estimation lies in the fact that it can only statistically establish correlation, leaving the researcher to infer causality and equivocate about the proper interpretation of results (Knapp 1998).

This dissertation will make use of a cross-sectional database and, thus, the criticisms described above apply. However, it should be noted that some researchers have used longitudinal data to address these criticisms. If property prices are available from periods before and after the introduction of an intervention (e.g., the construction of a new rail station), one can analyze the data as a "natural experiment" (Meyer

[11] In some cases the researcher may be aware of an unobserved factor and not have the data to properly control for it. In other cases the researcher may be entirely unaware of potentially confounding factors, which is understandable given the broad array of characteristics that influence property values.

1995). With such a research design, one compares the difference in property values after and before the intervention for affected (treated) properties to the same difference for unaffected (control) properties. This approach, often referred to as “difference in differences” estimation, provides statistical evidence of causality that a standard cross-sectional price model cannot provide[12]. Many recent studies have employed this method to evaluate the effect of various interventions on property values (Ellen & Voicu 2006, Chay & Greenstone 2005, Gibbons & Machin 2005, Galster et al. 2004).

Knaap (1998) points to several fairly universal findings from the empirical research about property values. In order to effectively isolate the effect of any factor on property values, the model specification should control for such primary drivers of property values. First, and fairly obviously, the size, age, and quality of any structure on a property, as well as the size of the property itself will have a strong influence on the value (Kain & Quigley 1970, Grether & Meiszkowski 1974). Next, the socio-economic characteristics of the neighborhood surrounding the property play an important role in determining value (Yinger 1979, Downing 1970). The location of a property within the region also has an effect. Early work focused on how property values (all other thing equal) decline with distance from the CBD (Jackson 1979, Brigham 1965). More recent studies illustrate how more general accessibility and proximity to secondary business districts also influence property values (Srour et al. 2002, Wadell et al. 1993). Finally, in terms of interregional variation[13] in property prices, studies usually point to demand factors (e.g., income levels, interest rates,

[12] As will be detailed in Chapter 3, the longitudinal data necessary for this type of analysis was not available for this research.
[13] This has less relevance to this research, as it will focus on a single region (San Diego).

employment, and population size), and land constraints (both natural and self imposed) as the main driver of this variation (Clapp & Giacotto 1994, Rose 1989, Manning 1989).

Beyond these general findings, researchers have found that many more specific factors influence property values. A sampling of some of these factors, albeit not comprehensive, is provided below:

- *Urban Amenities* – Proximity to open space (Irwin 2002, Peiser and Schwann 1993), parks (Nichols & Crompton 2005, Schroeder 1982), water bodies (Goetgeluk et al. 2005, Siderelis & Perrygo 1996), and neighborhood shopping (Song & Knapp 2003) have all been shown to positively influence property values.
- *Urban Disamenties* – Air pollution (Chay & Greenstone 2005, Smith & Huang 1995), noise (Nelson 2004, Mieszkowski & Saper 1978), traffic (Hughes & Sirmans 1992) and undesirable[14] land uses (Thibodeau 1990, Ihlanfeldt & Boehm 1987) have all been shown to lower property value.
- *Taxes and Regulations* – Research has shown that higher property taxes can lower property values (Bradbury et al. 2001, Oates 1969). Land use regulation/zoning has a complex relationship with property values (Pogodzinski & Sass 1990). It can increase property values by reducing nuisances and by creating supply constraints. It can reduce property values because it limits the development options of the property owner. As zoning will form a key component of the research presented in

[14] What is an “undesirable” land use depends on the property type being analyzed. The cited research focuses on single family homes and, therefore, commercial and industrial uses are considered undesirable.

Chapter 5, the influence of zoning on property values will receive a more detailed treatment in that chapter.

- *Public Services*[15] – High quality public schools (Downes & Zabel 2002, Jud 1985) and transportation services and infrastructure (which are the main focus of this research) have been shown to positively influence property values.

2.4 Transit Capitalization Literature

Precursor: Highway Capitalization

As a precursor to transit capitalization studies, researchers first sought to measure the capitalization benefits of highway investment. Studies conducted in the 1950's and 1960 have sought to analyze the effect of the many highway projects being constructed during that time period (Adkins 1958, Buffington & Mueth 1964). These studies found extremely large increases in property values associated with proximity to an interchange. More recent studies have been mixed. Ryan (2005) shows that commercial properties still benefit from good highway access while other studies show properties near highway interchanges sell at a discount because the associated nuisances (noise, traffic, pollution) overwhelm the accessibility benefits (Kim et al. 2007, Palmquist 1982, Langely 1981). This does not mean that freeway access has become unimportant but more likely that the large focus on highway construction since the 1950's has created an abundant supply of properties with good highway access (Giuliano 1995).

[15] The "public service" and "amenity" categories have some overlap. For example, amenities such as parks and open space are usually publicly owned and maintained.

Transit Capitalization Studies

Following the lead of these highway studies, recent research on the capitalization of accessibility has focused more on transit. Cervero (1997) provides a summary of over 40 capitalization studies conducted between 1970 and 1996 for North American transit systems. Several additional studies have been published in the intervening period and the following sections will cite many of these. The majority of these studies focus on single-family home prices (data for single family homes are presumably more available and simpler[16] to analyze) but some have also measured capitalization benefits for multi-family housing (Cervero & Duncan 2002a, Damm et al. 1980), offices (Bollinger et al. 1998, Cervero & Landis 1993), and commercial/retail properties (Cervero & Duncan 2002b, Landis et al. 1995, Damm et al. 1980).

Comparing and making generalizations about these studies presents difficulties as methodology and context vary greatly. The following sections will detail the various differences among these studies and how they might affect results. One might safely generalize from the body of literature that properties near stations sell at small to modest premiums (somewhere between 0 and 10 percent). Many reviews of the transit capitalization literature have come to similar conclusions (Ryan 1999, Cervero 1997, Huang 1996, Vessali 1996, Landis et al. 1995). Vessali (1996) estimates the average premium among a large group of transit capitalization studies at around 7 percent. The results from more recent studies also seem to fall roughly into this "modest" range (Hess & Almeida 2007, Kahn 2007, McMillen & McDonald 2004).

[16] Single family homes are the only property type where there consistently is a single unit on a parcel which belongs to a single owner.

Very few studies show either very large (Dewees 1976) or insignificant premiums (Ryan 2005, Gatzlaff & Smith 1993). It should be noted that even a comprehensive summary of publications likely provides a skewed general assessment since these studies may over-represent certain regions[17] and also because a finding of an insignificant premium or a discount may not find its way into publication.

Methodological Variation

The studies that make up the transit capitalization literature employ a variety of research designs. This can have a strong influence on the results and make meaningful comparisons across studies difficult. For example, the inclusion or exclusion of a key control variable can significantly alter the estimated benefits or station proximity. Thus an informed review of the literature requires an assessment of the methodological variation.

The *method of analysis* presents the first technical way that transit capitalizations studies can vary. The studies fall into three broad categories:

- *Hedonic Price Model* – Following along the broader literature, most transit capitalization studies estimate a cross-sectional hedonic price model that statistically isolates the impact of proximity to a station. A previous section (2.3) explained the theory and associated weakness of hedonic modeling.
- *Matched Pair Analysis* - Other studies have utilized a quasi-experimental matched pair analysis where the real estate values near a transit station are compared to a control area (Bernick et al. 1994, Cervero & Landis 1993, VNI Rainbow 1992,

[17] Portland, the Bay Area, and Atlanta have all been the focus of multiple capitalization studies.

Rybeck 1981). The obvious difficulty with such studies is that it is usually impossible to find a “true” control area that does not differ in ways other than station proximity. Cervero and Landis (1993) find very mixed results in their matched pair analysis (only sometimes did the station perform better than the control area), which they partially attribute to inherent weakness in this type of analysis. However, matched pair analysis may provide the best option when the systematic data necessary to specify a more robust model is unavailable.

- *Repeat Sales/Longitudinal Analysis*[18] - This group includes the limited number of studies that measure property values before and after the introduction of a rail system to see if the price near stations has increased more rapidly than those further away. The precise methodologies vary somewhat. Studies have made used of panel regression (Kahn 2007), “difference in differences” estimation, (Gibbons & Machin 2005), and repeat-sales price indices[19] (McMillen & McDonald 2004, Gatzlaff & Smith 1993, Faulke 1978). This type of research design presents the best way to make strong inferences about causality in the relationship between rail investment and property values. However, securing the longitudinal or panel data necessary for such analysis is difficult. For example, Kahn (2007) and Gibbons & Machin (2005) found it necessary to use aggregate data[20] in order to obtain the

[18] This group cannot simply be titled “repeat sales analysis” because it is possible to use repeated cross-sections in a “difference in differences” model.
[19] A housing price index based on repeat sales was developed by Bailey et al. (1963).
[20] Kahn (2007) uses census data - self reported home prices aggregated to census tracts. Gibbons & Machin (2005) use property sales transactions aggregated to London postal units.

panel necessary for their analyses, even though disaggregate data is standard[21] in analyzing property values.

The choice of *dependent variable* provides another way to distinguish among the studies. The sales price of a property is most often used for analyzing single-family properties and condominiums. Most non-residential and multi-family studies use monthly rents (Cervero & Landis 1993, Faulke 1978), although sales prices have also been used for these property types[22] (Landis et al. 1995, Cervero & Duncan 2002c). In a few cases, researchers have looked at land values instead of sales prices or rents. Knaap et al. (2001) found that rail positively impacted vacant parcels. However, it often proves very difficult to find a large enough sample of vacant land sales to estimate a model with any statistical significance. Others have used assessed land values of various property types, which are much more available than vacant property transactions (Cervero & Duncan 2002a, Cervero & Duncan 2002b, Alterkawi 1991). In either case, this strategy seems theoretically appropriate since the value of rail proximity (or any other neighborhood or regional characteristic) should affect the value of the land and not the structure. Using land price as a dependent variable eliminates the need to control for structure attributes. Depending on the quality and availability of variables measuring structure attributes[23], this may greatly improve the analysis. The downside to using assessed land values lies in that the researcher must

[21] Disaggregate data offer more precise information about a properties location and structure attributes. Data aggregation can also bias an analysis (McGuckin & Stiroh 2002).

[22] Only single family homes and condominiums are usually sold as single units. Because other property types often sell as large buildings with multiple units, the limited number of sales transaction often makes statistical analysis difficult. Using rents allows such property types to be analyzed by the unit and increases the number of observations included in the analysis.

[23] Most property sales databases include basic information about the property (e.g., size, number of bedrooms, age, etc.) but often lack measures of structure quality such as building materials and design.

rely upon the ability of the local assessor to appropriately apportion a property's value between structure and land[24].

Researchers have also used different approaches in measuring a property's proximity to rail station:

- *Station Adjacency* – A few studies, due to limitations of the data or research design, use a crude measure of whether a property is located in a census tract (or some other geographical unit) adjacent to a rail station[25] (Kahn 2007, Voith 1993 Voith 1991).
- *Time Savings* – Capitalization benefits are most directly related to the travel cost savings of being near a station. However, this is very difficult to quantify because it will highly depend on the desired travel destinations of the property owner/tenant. A few studies have made an effort to calculate the time savings associated with rail proximity and then used the measured time savings to predict property values (Allen et al. 1986, Bajic 1983, Dewees 1976, Boyce et al. 1972). Bajic (1983) uses a weighted travel time savings based on 5 potential destinations and Allen et al. (1986) measure commute time savings to the CBD.
- *Station Distance* – Most studies, especially the earlier ones, simply measure Euclidian (as the crow flies) distance to the nearest station. More recent studies

[24] Using assessed land values was considered and tested for this research. However, the San Diego County Assessor's office would not divulge the process by which they apportion value to land and structure. Given this lack of knowledge, it was decided that the full sales price of a property would be used as the dependent variable.
[25] An "adjacent" tract might be defined as a tract with a station in it or a tract that falls with a certain buffer. Kahn (2007) defines "treated" tracts as those within 1 mile of a station.

have moved to using network/walking distance[26] (Hess & Almeida 2007, Bowes & Ihlanfeldt 2001, Weinberger 2001, Lewis-Workman & Brod 1997, Landis et al. 1995). The use of network distance provides a significant methodological improvement because using Euclidian distance systematically overstates rail proximity in areas with a circuitous street network (usually suburban locations). In terms of how the distance measure is manipulated for use in a model, studies have used both binary and continuous (sometimes transformed[27]) variables. Most studies have utilized a binary variable (or a series of binary variables) that indicate if a property is within a given distance of a station, usually ¼ or ½ of a mile. The binary variable approach has the advantage of having a simple interpretation. A series of binary variables can also provide an empirically derived form of the price gradient rather than relying on the researcher to apply the proper transformation of a continuous variable. However, this approach discards information (i.e., the distance variation within the binary category) and provides a choppy and often unrealistic price gradient[28].

The set of control variables specified in a model provides another way that studies differ. Some have a large and rich set of control variables while others have a much more limited set. Most studies have basic structure controls (e.g., size, bedrooms, bathrooms, age). A few have more detailed characteristics (e.g., building materials, central air conditioning, or the presence of a view, pool, or fireplace)

[26] GIS software makes the calculation of network distance fairly simple. The increased use of GIS in academic research during the 1990's coincides with the use of network distance to measure transit proximity.
[27] Studies have mostly used a simple linear variable but some have used a quadratic function to capture the disammenities associated with very close proximity to a station (Nelson 1992)
[28] For these reasons, a continuous rail distance variable is used in this research.

(McMillan & McDonald 2004, Voith 1993). In terms of regional characteristics, most have some measure of CBD proximity and some also have more sophisticated measures of regional employment accessibility (Bowes & Ihlanfeldt 2001, Cervero & Duncan 2002a). Many studies make good use of census data for neighborhood controls (e.g., income, housing density, employment density). This is commonly done by directly assigning the attributes of a single census tract to a property. GIS has made it easier to calculate more sophisticated neighborhood measures that aggregate data from multiple tracts when a property falls near a tract boundary (Cervero & Duncan 2002a, Cervero & Duncan 2002b). Weinberger (2001) has implemented an alternative strategy in using a series of dummy variables representing each traffic analysis zone (TAZ) in the study area. This does an excellent job of controlling for unobserved neighborhood and regional factors. On the other hand, these fine-grained dummies may capture some of the effect of rail proximity and bias the rail distance coefficient downward. Making comparisons about the about the validity of one specification over the other is difficult and possibly unfair because, in a given context, certain control variables may prove insignificant or unnecessary. For example, if the study area is small and homogenous, the model specification may not require a large set of controls (Lewis-Workman & Brod 1997, Gatzlaff & Smith 1993). However, all things equal, one would expect that models with a rich and sophisticated set of controls provide a more accurate assessment of transit capitalization.

Contextual Variation

An informative review of the literature would provide an assessment of the prospects of rail capitalization benefits across regions, time, and transit technology. However, except for the few studies that examine contextual variation using a common methodology[29] (Kahn 2007, Lewis-Workman & Brod 1997, Landis et al. 1995), it is impossible to make true comparisons across contexts. Thus, the findings have generally proved mixed and difficult to reconcile. The following sections will present how contextual variation might theoretically affect capitalization benefits and how well the empirical literature supports the theory:

- *System Type* – Studies have focused on heavy, commuter, and light rail transit systems that provide varying levels of accessibility. In a US context, no research has been done on bus transit, as many believe, rightfully or not, that capitalization benefits are only conferred to fixed-guideway systems with faster speeds and more permanent infrastructure (Barker 1998, Cervero 1997). Rodriguez and Targa (2004) provide evidence that the rapid bus system in Bogotá, Colombia does confer significant capitalization benefits. In terms of rail, one would expect grade-separated heavy rail and, to a lesser degree, commuter rail systems to generate greater capitalization benefits than the slower and lower capacity light rail systems. Landis et al. (1995) find that the BART heavy rail system confers greater capitalization benefits than surrounding light rail systems in San Jose, Sacramento, and San Diego. Cervero & Duncan (2002b, 2002c) find that commuter rail systems generally perform better than light rail in both San Diego and San Jose. However,

[29] However, if the methodology is bad or inaccurate any inference about contextual variation become suspect.

this pattern does not always hold true. Gatzlaff & Smith (1993) find that the heavy rail system in Miami provides no capitalization benefits and Bowes & Ihlanfeldt (2001) find limited benefits for the heavy rail in Atlanta. Meanwhile, several studies have found significant premiums for the light rail system in Portland (Knaap et al. 2001, Lewis-Workman & Brod 1997, Al-Mosaind et al. 1993). These confounding results may have more to do with the respective regions (as discussed in the next section) than the transit technology.

- *Geographic Context* – Each study area will have its own unique economic and institutional conditions, spatial configuration, and built environment that may affect transit capitalization. For example, regions that put a policy focus on transit-oriented development, such as Portland (Dueker & Bianco 1999), may generate greater capitalization benefits than an otherwise similar region. The previously cited studies showing significant premiums in Portland provide evidence of this. Additionally, transit should have a greater impact in dense and congested pre-war regions with higher shares of transit use (e.g., New York, Chicago, San Francisco, and Boston). Lewis-Workman & Brod (1997) analyze rail capitalization benefits in 3 regions and found that premiums roughly correlated with the size and density of the regions[30]: (1) New York, (2) San Francisco (3) Portland. However, it is possible that this results from the size and quality of the rail system in the respective regions. Every region has so many unique attributes that it is difficult to attribute differences in transit capitalization to any one factor. Kahn (2007) examines the capitalization benefits for new rail systems in 14 cities of varying

[30] This study only analyzed a small portion of each region which may bias the results.

sizes, densities, and auto-orientation and his finding show no clear pattern as to what kind of city benefits the most.

- *Time Context* – The time between the study period and the opening of the rail system varies from study to study. This can affect the research findings because it often takes time for the accessibility benefits of a new investment to be recognized and assimilated into the property market, although many studies show capitalization occurring before service actually commences (McMillan & McDonald 2004, Knaap et al. 2001, Ferguson et al. 1988, Damm et al. 1980). McMillan & McDonald (2004) trace the effect of a rail extension in Chicago over time and find the capitalization effect begins at the announcement of the extension, increases rapidly after actual operations commence, and then slightly decrease in the following years (presumably because of the supply response). Independent of the age of a rail system, economic conditions during the study period can influence findings. For example, a growing economy often leads to traffic congestion, causing the accessibility benefits of being near transit increase. Several studies have analyzed the effects of rail proximity on property markets in Santa Clara County, CA during the height of that area's technology boom (Cervero & Duncan 2002a, Cervero & Duncan 2002b, Weinberger 2001). These studies have shown large premiums for both commercial and residential properties. Conversely, Landis et al. (1995) found no transit capitalization when they studied the same region at an earlier period (the early 90's) with a weaker economy. The rail system also expanded and matured during the economic boom, making it difficult to know how much to attribute the growth in capitalization benefits to the performance of the regional economy.

In broadly assessing the literature, some weak patterns seems to emerge but making concrete empirical generalizations about the potential for capitalization in a given context proves difficult. An accurate appraisal of the capitalization benefits in a given region will likely require a well-designed study of that region.

2.5 The Conditional Nature of Transit Capitalization

One common weakness of previous transit capitalization studies is that the methodologies assume transit proximity is independent of other factors (within a given region). In other words, they assume that being near a transit station has the same impact on a property regardless of where and what it is. As a result most studies produce a single premium finding that applies to the entire study area (e.g., being ¼ miles from a station adds $5,000 to the sale price of home). While this often gives an accurate measure of the *average* premium within the study area, it misses potentially large amounts of variation in premium size (Huang 1996). Premiums may vary from station to station and even parcel to parcel because of transit-oriented neighborhood characteristics, zoning policies, local accessibility and congestion levels, and individual property characteristics. In a properly situated location, station proximity might generate premiums well above the range (0-10 percent) typically found when looking at a region-wide average. Other locations in the same region might generate very little premium or a discount. A study that averages the premium for the entire region helps in answering whether capitalization occurs but provides no specific information that might help planners and policy makers. Conversely, knowledge of how location and property characteristics condition premiums could prove very useful in terms of planning and designing station areas, as well as picking station locations for new systems.

Given the potential value of analyzing premium variation, it is surprising that more of the previous transit capitalization research has not gone in this direction. Many of the previously cited studies provide some caveat as to how the right conditions need to be in place for capitalization and land use impacts to occur but little has been done to test for this (Huang 1996, Knight & Trygg 1977). Some researchers have started to get at the conditional nature of transit capitalization by geographically segmenting their analysis into sub-regions (McMillan & McDonald 2004, Cervero & Duncan 2002c, Gatzlaff & Smith 1993, Nelson 1992, Faulke 1978). Cervero and Duncan (2002c) found different levels of capitalization in San Diego along various segments of the rail system[31]. Nelson (1992) segments his analysis into areas north and south of a rail line in Atlanta and finds homes on the lower income side receive greater capitalization benefits. One problem with this segmentation approach is that it can reduce the sample size in any given geographic segment to the point where findings have very limited statistical significance (Gatzlaff & Smith 1993).

While looking at regional sub-areas does illustrate variation in capitalization benefits, it largely leaves open to interpretation what sub-regional characteristics drive the variation. Bowes and Ihlanfeldt (2001) provide the first transit capitalization study

[31] They found commercial property faired best in the CBD and along the most commercial segment of the rail line, residential property faired well along the more residential segment, and nothing fared very wall along the industrial segment.

(at least of which this author is aware) that statistically tests the interaction between station proximity and specific attributes of a location. In their work they test the interaction of station proximity with CBD proximity, neighborhood income, and the presence of a park and ride lot[32]. They find that properties further from the CBD gain larger capitalization benefits[33], that properties surrounding park-and-ride stations gain greater benefits at an intermediate distance (between ½ and 1 mile), and that lower income neighborhoods gain greater capitalization benefits at very close distances (within ¼ mile).

This research will build upon the work of Bowes & Ihlanfeldt (2001) by testing for interactions between station proximity and a large suite of location and property attributes. More specifically, subsequent chapters will provide a theoretical explanation and statistical evidence as to how housing type (single family or condominium), zoning, the built environment, and transit service quality can condition the size of rail transit capitalization benefits in San Diego, CA.

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[32] They also tested for interactions with the level of bus service and whether the station was underground and found that these interactions were not significant.

[33] They reason that rail can gain a competitive advantage at further distances when the line-haul portion of a trip gains importance.

Chapter 3. Research Design

3.1 Research Hypotheses

As pointed to by the previous chapters, this research will empirically examine whether the characteristics of a property and its location can condition the size of capitalization benefits generated by proximity to rail transit stations. There obviously exist many things that might condition such benefits and this research cannot test for all of them. The analysis will focus on testing how elements of TOD condition capitalization benefits. Many look to TOD as a way to redress urban problems such as congestion, pollution, and sprawl (Cervero et al. 2002). There has been and will continue to be debate as to the ability of TOD to provide the desired remedies (Boarnet & Crane 2001, Cervero 2002). Whether a market exists for such development seems an important part of this debate (Levine 2005). Therefore, examining how facets of TOD affect the market viability of station area properties presents a very policy relevant line of research. General speaking, it is expected that some market synergy exists between the concentrated and mixed-use development that characterize TOD and station proximity. Most research shows that rail transit generates premiums mostly below 10 percent (as detailed in the previous chapter). However, these numbers largely reflect regional averages. When optimally situated, presumably in a TOD setting, property near stations might be expected to sell at premiums in excess of 20 percent. The following chapters will test several specific hypotheses in this regard:

1) ***Condominiums receive greater capitalization benefits from station proximity than single family homes (Chapter 4).***
2) ***Permissively zoned single-family properties receive greater capitalization benefits than restrictively zoned properties (Chapter 5).***
3) ***Condominiums in walkable neighborhoods receive greater capitalization benefits than those in more auto-oriented neighborhoods (Chapter 6).***
4) ***Condominiums receive greater capitalization benefits when near a station that provides better/more competitive transit service (Chapter 6).***

A more detailed discussion of theoretical expectations and the empirical results will be presented in the identified chapters. The following sections of this chapter will detail the study area, data, and analysis method used to test these hypotheses.

3.2 Study Area Description

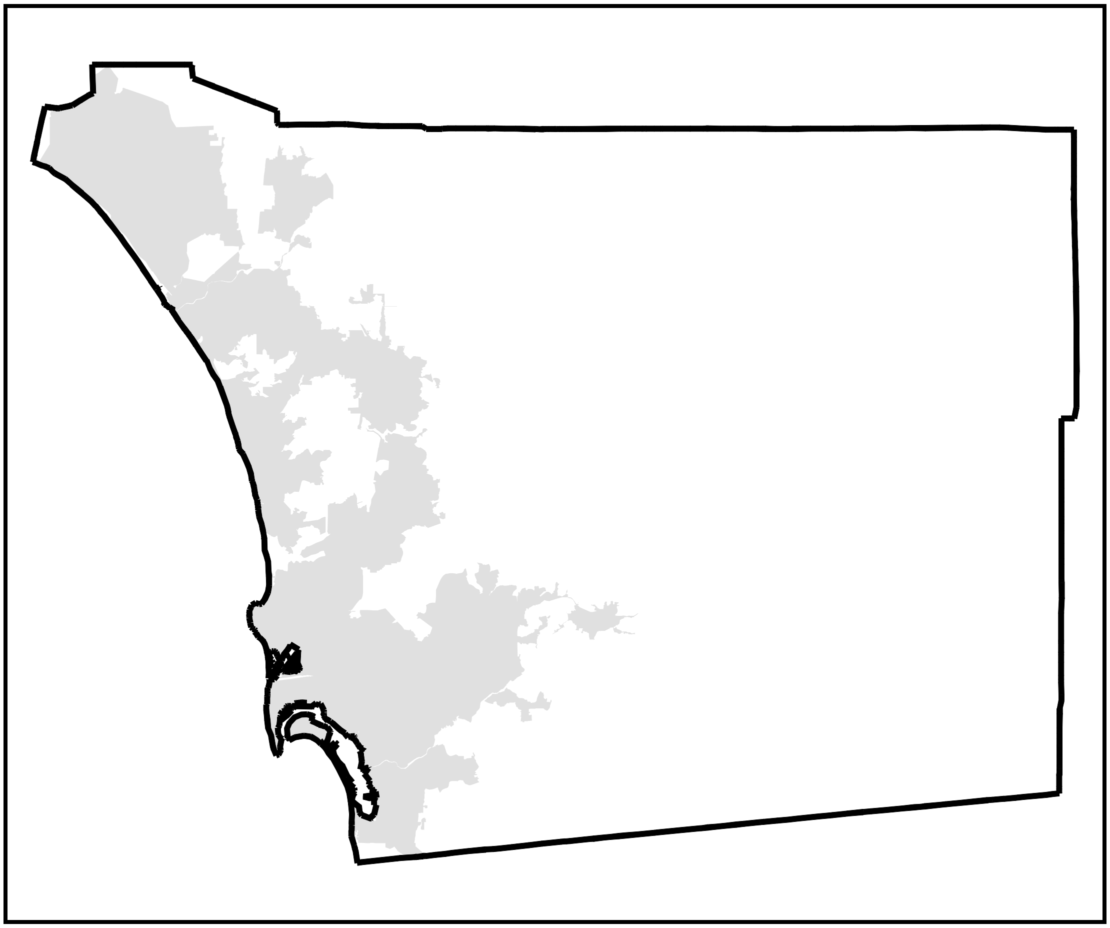
The San Diego metropolitan statistical area (MSA) served as the study area for this research[34]. The MSA has 4,200 square miles located in the very southwest corner of the continental US. Figure 3.1 shows the location of the San Diego MSA within California and the western region of the US.

[34] The San Diego MSA is made up of only one county. This means that the San Diego MSA and San Diego County are geographically interchangeable.

Figure 3.1. Location of the San Diego MSA

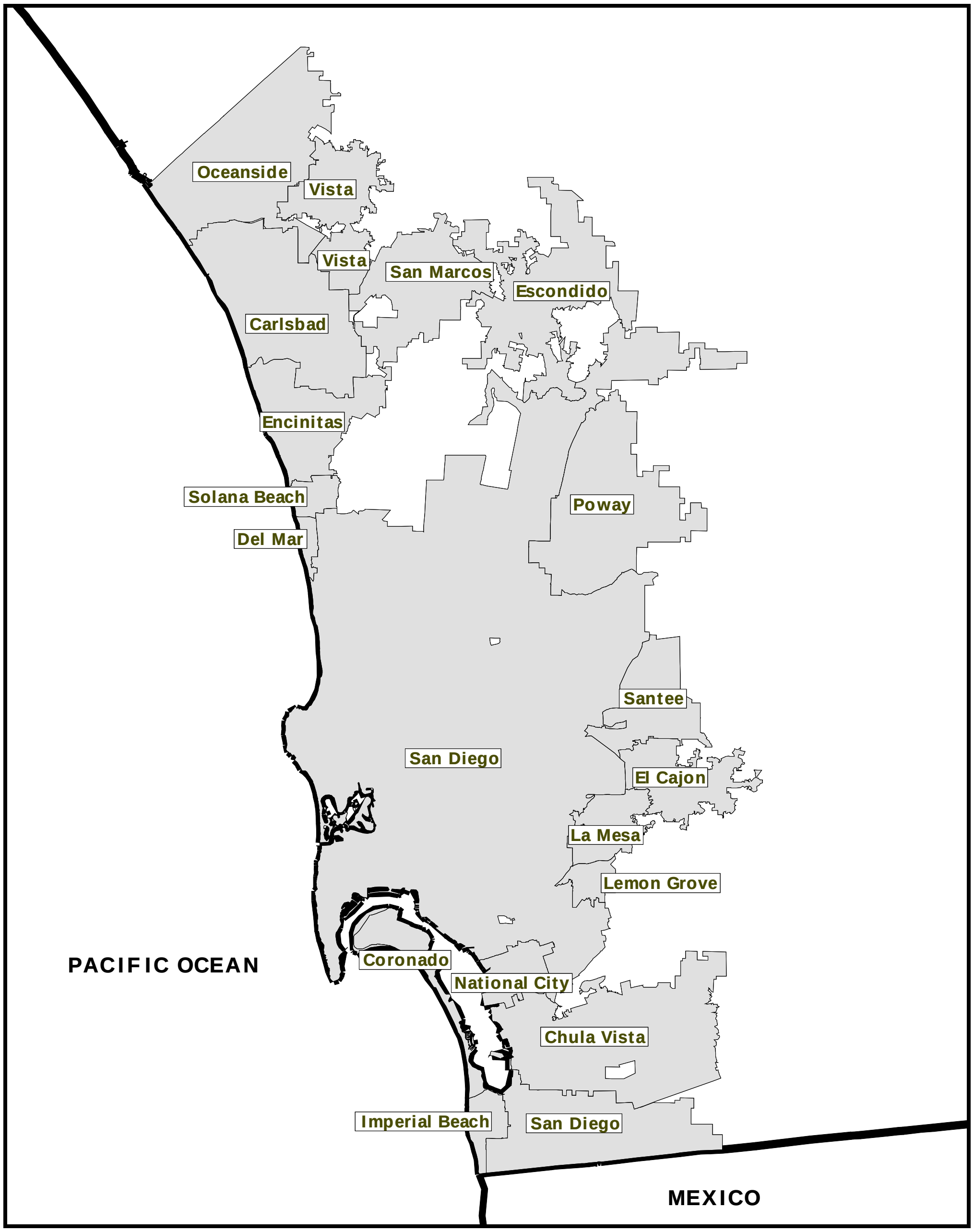
The MSA had a population of 2.8 million people at the 2000 US census. Over 95 percent of the population resides in less than 800 square miles of urbanized area along the pacific coast line. Outside of the urbanized area, the rest of the region is mostly mountains or dessert. Figure 3.2 displays the urbanized area within the MSA.

Figure 3.2. Urbanized Area within the San Diego MSA (urbanized area in Grey)



The MSA contains 18 municipalities, all of which fall in the urbanized western edge of the region. Figure 3.3 provides a map of the various municipalities.

Figure 3.3. Municipalities in the San Diego MSA

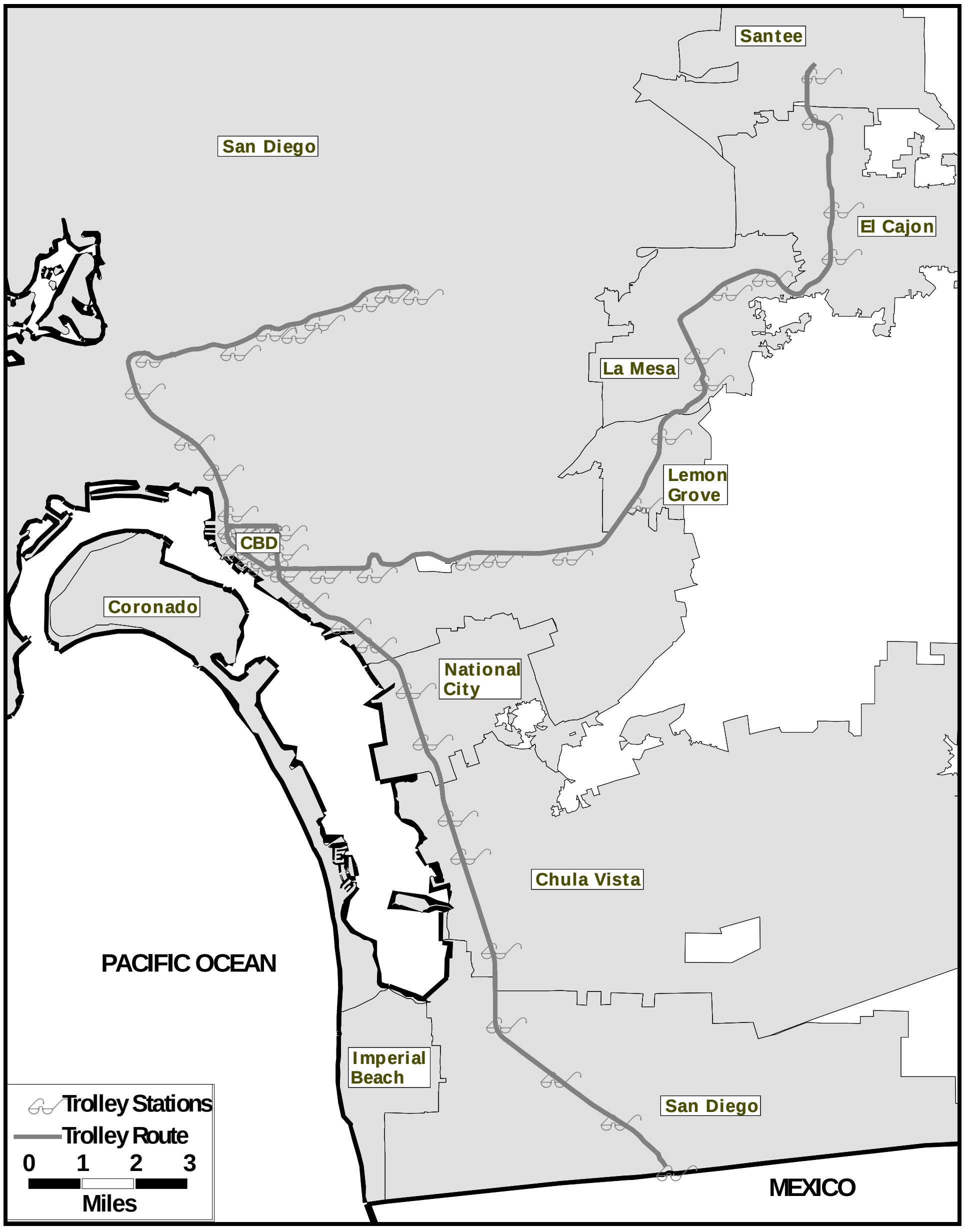


The dominant and by far the largest municipality is the City of San Diego which has over 300 square miles and about 1.2 million people.

Much of the region developed in the automobile era and is fairly auto-oriented, although it has developed at higher densities that many MSAs because it has seen rapid growth (immigration and retirees) while having land constraints (ocean, dessert, and mountains).

The MSA is served by relatively recently introduced light rail and commuter rail services. The San Diego Trolley is a light rail system that began service in the early 1980's with about 20 track miles and 19 stations. The system has had several stages of expansion to now include 53 stations and 50 track miles, with the last 4 stations opening for service in 2006. Figure 3.4 provides a map of the Trolley line and stations.

Figure 3.4. San Diego Trolley Light Rail Lines[35]



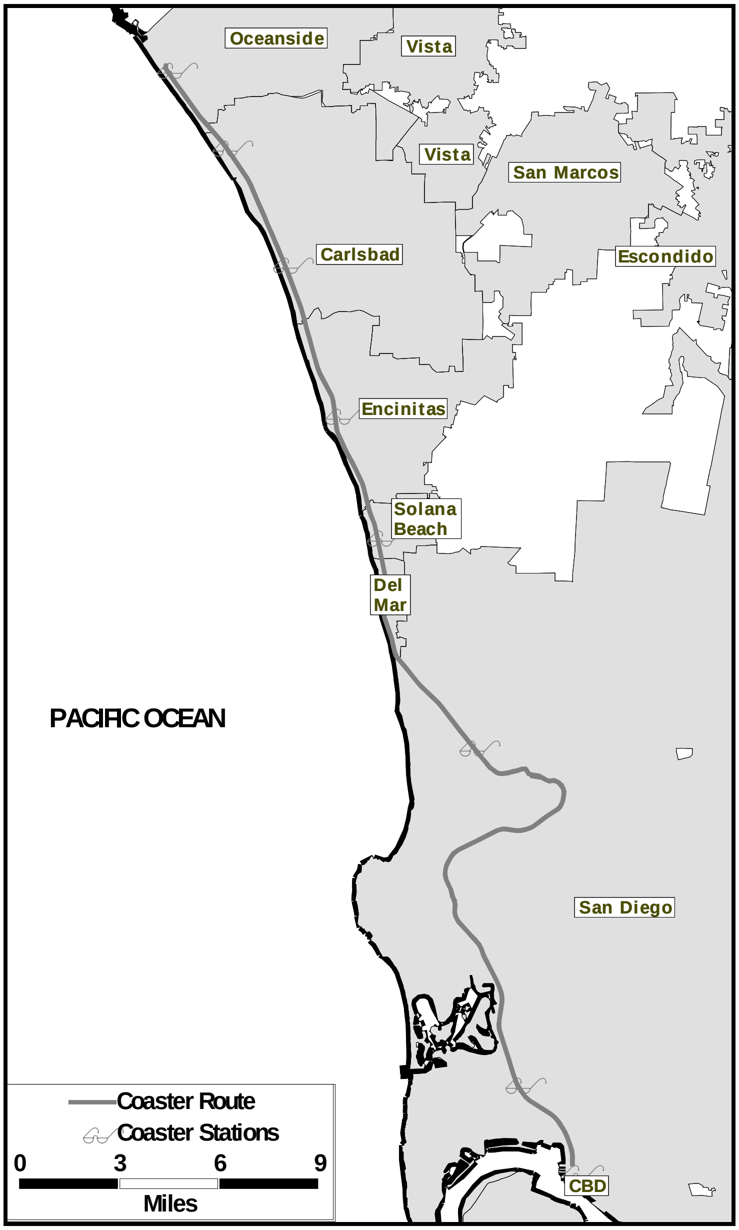
The service radiates from the San Diego CBD to the north, south (to the Mexican border), and east. It has up to 7.5 minute peak hour headways. Forty of the stations fall within the city of San Diego, with a handful of stations to the east in Lemon Grove (2),

[35] This map excludes the 4 newest stations, which were added after the study period.

La Mesa (3), El Cajon (3), and Santee (1) and to the south in National City (2) and Chula Vista (2).

The Coaster is a commuter rail line that commenced services in 1995. It runs about 40 miles and serves 8 stations along the coast between downtown San Diego and the northern end of the MSA (near the Orange County border). Figure 3.5 presents a map of the Coaster system.

Figure 3.5. Coaster Commuter Rail Lines



The Coaster stations are located in San Diego proper (3), Solana Beach (1), Encinitas (1), Carlsbad (2), and Oceanside (1). It operates mostly during peak hours and in peak directions on 40 minute headways. The Oceanside station (the northern Coaster terminus) also serves as the southern terminus for Metrolink, which is the commuter rail system for the Los Angles region. The two stations closest to downtown San Diego are shared by the Coaster and the Trolley. The Coaster also shares 4 stations with the Amtrak Pacific Surfliner.

The San Diego region served well for the purposes of this research for several reasons:

1) Foremost, it has a good number of stations (around 60) with a wide range of station neighborhoods in terms of densities, land use mixtures, and socio-economic characteristics, and zoning regulations. Testing for interactions with station proximity requires this diverse set of rail served locations.
2) The presence of commuter rail and light rail allowed a comparison of how the different levels of service quality provided by these systems (i.e., the trade off between the faster speeds of the commuter rail versus the more frequent service and more centrally located light rail) affect capitalization benefits.
3) Since San Diego is a fast growing, auto-oriented region, the findings will hopefully have some external validity in a US context. A more transit-friendly region (e.g., New York, Chicago, or San Francisco) would likely show more pronounced capitalization benefits but would not translate to the majority of American cities. Conversely, Phoenix, Sacramento, Denver, Portland, Seattle, and Salt Lake City are all western regions with existing or planned light rail systems (and also commuter rail in some cases) that make a decent comparison to San Diego in terms of size and growth patterns. However, even with such similarities, it must be recognized that each region has its own unique attributes and this makes for only cautious generalizations.

3.3 Database of Sales Transactions

A database of recent property sales transactions within the San Diego MSA was obtained from a commercial vendor[36]. For all parcels in the region, this database provided the most recent sales transaction through 2001. A series of filters was applied to this database to obtain the subset of data appropriate for the analysis:

- *Missing Data* – As with any large database, some records had missing and detectably bad information for certain data fields. After thoroughly exploring the database it was determined that the pattern of missing/bad data was random and the number of affected records was small. Therefore, imputation was deemed unnecessary and these records were simply dropped without fear of creating bias.
- *Arms Length Transactions* – Any transactions not considered to be conducted on the open market were removed from the database. Upon consulting with the San Diego County Assessor's Office, a transaction was considered to be at arms length if the sales price was within 5 percent of the assessed value[37].
- *Property Type* – This research focuses on condominiums and single family homes. To get a full picture of transit capitalization, it is clearly important to look at all property types. However, because time and resources did not permit a full analysis for all property types, a detailed focus is put on these two. Condos and single family homes were chosen for two reasons. First, comparing the effect of transit capitalization on these property types is straightforward because they are both

[36] First Real Estate Solutions provides a database of property sales transaction called "Metroscan", which was acquired for this research.
[37] The assessed value used in this calculation is the original assessed value at the time of the sales transaction.

characterized by single unit purchases (unlike multi-family rental and non-residential property that is bought and sold as multiple unit complexes). Second, because these property types are sold as single units, there were many more sales transactions to analyze. Given that this empirical analysis included multiple interaction terms, producing statistically significant results required a large number of observations. It is hoped that some of the methodology applied in this research can later be applied to other property types.

- *Time Period* – Sales transactions that occurred between 1997 and 2001 were used in the analysis. This five year study period was a compromise chosen after evaluating the costs and benefits of a short versus long study period. A short study period limits the number of observations available for analysis. It also limits external validity because a short study period might lead to findings only applicable to that limited time period. On the other hand, in the specific case of this research, a longer study period would lead to a temporal mismatch between dependent and independent variables. Many of the control variables for this study came from the 2000 US census and 2000 land use data. For transactions that occur too long before 2000, the control variables may not reflect the reality "on the ground" at the time of sale. Using sales between 1997 and 2001 allowed 5 years of temporal variation without getting to far removed from the 2000 control data. The housing price index for the San Diego region (provided by the US Office of

Federal Housing Enterprise Oversight) was used to adjust all sales prices into constant US dollar values from the first quarter of 2000[38].

- *Geographic Extent* - The analysis was limited to properties within 1 network mile of one of the region's rail stations, a distance that roughly coincides with a 20 minute walk. Exploratory analysis in the initial stages of this research indicated little capitalization impact beyond this point. Similar results were found even when stratifying the analysis by the presence of park and ride lots, which might be expected to create impacts further from the station. Other transit capitalization studies also rarely show benefits beyond ½ mile (Ryan 1999, Cervero 1997). Therefore, it was determined that properties beyond 1 mile would provide little extra information in terms of transit capitalization[39]. Exclusion of these properties from the analysis had several advantages. Determining the functional form of the rail proximity variable became much simpler as did measuring interactions with rail proximity[40]. Additionally, reducing the geographic area of analysis made it more homogenous and easier to fully specify a model. Areas beyond 1 mile of a station are more likely to be exurban and even rural. Such areas probably form a fundamentally different real estate market where certain property and

[38] Using monthly and quarterly dummies variables was also tested as a way to control for price appreciation. This did not change the results so the simpler approach of converting prices to constant dollar values is used.

[39] This does not mean that the ability to live at longer distances and drive (or ride) to a rail station has no value. Instead, this spatial concentration of capitalization benefits likely results from the fact that the supply of property within a convenient driving distance of a station is far greater than the supply within walking distance. This is compounded by the fact that the limited number of parking spaces provided at stations might artificially reduce demand for park-and-ride.

[40] Limiting the analysis to only properties within 1 mile allowed the use of a single continuous variable for rail distance. Beyond one mile, the price gradient flattens so quickly that it would require a piecewise function to capture an appropriate functional form. Creating interaction terms for a piecewise function would require multiple interaction terms for each variable that was interacted with rail proximity.

neighborhood characteristics are valued differently than in the more centrally located rail corridors. Focusing the analysis on properties within the first mile allowed for a model more precisely estimated to the type of neighborhoods found within the rail corridors.

- *CBD Properties* – Properties in the San Diego CBD were also excluded from the analysis[41]. Since there is a downtown loop of closely spaced trolley stations, almost all properties in the CBD are within ¼ mile of a station. There are no comparably desirable locations not near a station, making it difficult to disentangle the effect of the unique CBD location from rail proximity. These properties were excluded to avoid conflating the value of a CBD location with rail proximity.
- *Property Size* – The analysis was limited to properties with less than 3,000 square feet of floor space. This upper bound was set because there were about 20 luxury condominiums above this threshold that were generating extreme residuals. For the sake of consistency, the same limit was set for single family homes.

After applying the various filters described above, 4,970 single family and 4,166 condominium properties were available for model estimation.

3.4 Hedonic Price Models

General Model Description

[41] For the purposes of this research, a property was defined as being in the CBD if it was faster to walk to the center of the CBD (Horton Plaza) than it was to get there by rail (including access and egress time). No single family properties met this criterion so only condominiums were excluded.

This research used cross-sectional, multiple regression analysis to estimate a series of hedonic price models that predict property values for condominiums and single family homes. The hedonic price approach was chosen because it provided the best way to statistically isolate the capitalization benefits of transit, given the data available[42]. The models use proximity to rail stations, a rich set of control variables, and interaction terms between station proximity and other key variables to predict the sales price of housing unit.

The subsequent chapters will present several models designed to test the previously outlined hypotheses about the conditionality of rail transit capitalization. While there will be differences among the models presented, they will generally take the following form:

$$\mathbf{P}_{\boldsymbol{i}} = \boldsymbol{f}(\mathbf{S}_{\boldsymbol{i}}, \mathbf{N}_{\boldsymbol{i}}, \mathbf{J}_{\boldsymbol{i}}, \mathbf{R}_{\boldsymbol{i}}, \mathbf{R}_{\boldsymbol{i}}^{*})$$

Where:

$\mathbf{P}_{\boldsymbol{i}}$ = the sales price of property $\boldsymbol{i}$

$\mathbf{S}_{\boldsymbol{i}}$ = site characteristics for property $\boldsymbol{i}$

$\mathbf{N}_{\boldsymbol{i}}$ = characteristics of the neighborhood surrounding property $\boldsymbol{i}$

$\mathbf{J}_{\boldsymbol{i}}$ = characteristics of the jurisdiction in which property $\boldsymbol{i}$ is located

$\mathbf{R}_{\boldsymbol{i}}$ = property $\boldsymbol{i}$'s proximity to a rail station

$\mathbf{R}_{\boldsymbol{i}}^{*}$ = interaction terms between $\mathbf{R}_{\boldsymbol{i}}$ and other variables

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[42] A longitudinal analysis might serve the purposes of this analysis better, especially in terms of determining causality. However, a database sufficient for this type of analysis was not readily available for the San Diego MSA.

Interaction Terms

The interaction terms in the following models will provide the key findings for this research. These interaction terms allow for statistical testing of how various attributes of a property and location condition the impact of rail proximity. The specific interactions analyzed in this research will be introduced in more detail in the following chapters.

Creating interaction terms in a regression model simply requires multiplying two independent variables together and including the product as an additional independent variable in the model. The proper interpretation of coefficients and calculation of standard errors for interaction terms requires some additional sophistication (Friedrich 1982). Therefore, a brief technical discussion of interaction terms will follow.

In regression equation form, an interaction between variables $\mathbf{X_1}$ and $\mathbf{X_2}$ would go as follows:

$$\mathbf{Y = (b_1*X_1) + (b_2*X_2) + (b_3*X_1*X_2)}$$

The first two terms are constitutive (the individual components of the interaction) and the third term is the actual interaction. With the interaction term in place, the actual coefficient for $\mathbf{X_1}$ is no longer simply $\mathbf{b_1}$ but rather[43]:

$$\mathbf{b_1 + (b_3*X_2)}$$

As the previous formula makes clear, $\mathbf{b_1}$ (the coefficient for the constitutive term) is now interpreted as the "true" coefficient for $\mathbf{X_1}$ only when $\mathbf{X_2}$ is equal to 0.

[43] Similarly, the coefficient for $\mathbf{X_2}$ becomes $\mathbf{b_2 + (b_3*X_1)}$.

Just as the interaction causes the coefficient of $\mathbf{X_1}$ to depend upon the value of $\mathbf{X_2}$, the standard error of this coefficient also depends upon the value of $\mathbf{X_2}$. The standard error for $\mathbf{b_1 + (b_3 * X_2)}$ is calculated by taking the square root of the following equation:

$$\mathbf{variance(b_1) + (X_2^2 * variance(b_3)) + (2X_2 * covariance(b_1 b_3))}$$

This equation provides two important insights (Brambor et al., 2006):

(1) It is important to keep constitutive terms in the model even when not statistically significant. If $\mathbf{X_1}$ is removed from the model because $\mathbf{b_1}$ is not significantly different from 0, it also requires the assumption that $\mathbf{variance(b_1)}$ and $\mathbf{covariance(b_1 b_3)}$ are also 0. If the constitutive term for $\mathbf{X_1}$ is removed, the calculation of the coefficient for $\mathbf{X_1}$ would then simply become $\mathbf{b_3 * X_2}$, which might be fairly accurate considering that if $\mathbf{b_1}$ is not significant, it will likely be close to 0. The associated standard error would be calculated as just $\mathbf{(X_2^2 * variance(b_3))}$, which would be inaccurate because $\mathbf{variance(b_1)}$ and $\mathbf{covariance(b_1 b_3)}$ are extremely unlikely to be 0. Therefore, it is necessary to include $\mathbf{X_1}$, significant or not, in order to provide all the variance and covariance estimates needed to calculate accurate standard errors and conduct significance tests.

(2) Even if $\mathbf{b_1}$ and $\mathbf{b_3}$ are not significant, $\mathbf{X_1}$ can still significantly affect the dependent variable at certain values of $\mathbf{X_2}$. If $\mathbf{covariance(b_1 b_3)}$ is large and of the opposite sign of $\mathbf{X_2}$, the standard error calculation can be small, even if the variance for $\mathbf{b_1}$ and $\mathbf{b_3}$ is large. Therefore, any potential interaction should never be dismissed as insignificant until testing the significance of $\mathbf{b_1 + (b_3 * X_2)}$ for key values of $\mathbf{X_2}$.

Based on these observations, a handful of insignificant constitutive and interaction terms have been left in models that might otherwise have been excluded.

Functional Form of Dependent Variable

The untransformed (linear) sales price of a property was used as the dependent variable for all models. Determining the functional form of the sales price variable did require some deliberation. Several recent published studies of real estate price models have successfully used a semi-log model in which the natural log of sales price serves as the dependent variable (Song and Knapp, 2003, Eppli and Tu, 1999). For the research at hand, the main advantage of the semi-log model was that it eliminated heteroschedasticity, which was strongly present when using an untransformed sales price variable. However, the semi-log model was not used because it likely does not provide the best way to represent rail proximity premiums (as discussed below). Instead, heteroschedasticity was accounted for by employing a "heteroschedasticity-consistent" estimation of standard errors[44,45] (Long and Ervin 2000).

With a logarithmically transformed dependent variable, the estimated coefficient of an independent variable can be interpreted as the percent change in the dependent variable with a one unit increase (or decrease) in that independent variable.

[44] A weighted-least squares (WLS) approach was initially attempted to correct for heteroschedasticity but the model coefficients were highly subject to which variable was used as the weight. Since it was impossible to tell which weighting variable provided the most accurate coefficients, the WLS approach was abandoned.

[45] In the presence of heteroschedasticity, OLS regression can produce biased standard errors, although coefficients should still be unbiased. A heteroschedasticity-consistent estimator employs a method of calculating standard errors that does not assume homoschedastic error and, therefore, provides more accurate standard errors in the presence of heteroschedasticity. The coefficients remain the same as they would be in OLS estimation. The "robust" option in STATA, which was used in model estimation, allows for the calculation of heteroschedasticity-consistent standard errors.

It does not seem that proximity to rail would affect property values in this manner. For example, a semi-log model might produce the following general finding: being within ¼ mile of a station increases property values by 10 percent. This means that, in terms of raw dollar values, a large luxury housing unit would gain much more from transit proximity than a more modest unit. The buyers of more expensive properties will, in all probability, have higher incomes and a higher value of time (Small et al. 2005). To the degree that rail proximity can provide time savings, it might be argued that premiums for rail access are best measured as a percentage (with a semi-log model). However, in most situations transit will never match the auto in terms of travel time. For many, the real benefits of good transit access come from savings garnered from avoiding costs associated with the automobile (parking, fuel, and fixed ownership costs). For others, the benefits of rail proximity come from personal or ideological preferences for transit. It seems more likely that the benefits of transit proximity pass directly into a property's sales price regardless of the underlying price. Therefore, an untransformed sales price variable was used so that the coefficient for rail proximity expresses premiums in raw dollar values.

Independent Variables

Many variables were gathered for this analysis. The following section will provide a general description of the variables, including the method of calculation and the underlying data source where appropriate:

- *Site Characteristics* - The "Metroscan" database acquired for sales transactions also provided the basic site characteristics included as independent variables in the models: Building floor area, lot area[46], structure age, number of bathrooms, number of bedrooms, number of garage spaces, and whether the unit has a view[47] or a pool.

- *Neighborhood Characteristics* - A very large set of socio-demographic, housing, employment, road network, and land use measures was calculated for the neighborhood around each property. The source data for these measures came from:

  (1) 2000 US Census “place residence” and “place of work” data, mostly at the block group level but also by block when data was available at that level.

  (2) A detailed year 2000 land use layer with nearly 100 land use categories created and provided by the region’s metropolitan planning organization (SANDAG).

  (3) A road layer with detailed link classes, speeds, and road widths acquired from the region’s GIS repository (SanGIS).

  Each property in the analysis was located in a GIS parcel database[48] and then the above listed data was aggregated into buffers[49] around each property. Data was aggregated into buffers of ¼, ½, ¾, and 1 mile. For most variables, the ¼ mile buffer proved to have the strongest statistical effect on property values and, therefore, the ¼ mile measures were used exclusively in the models. In addition, in cases where very close proximity to a neighborhood feature might have a strong

[46] For condominiums, lot area doesn’t have direct relevance because units usually share a lot. Instead, the average lot area per unit (within a condominium complex) was used in place of lot area.
[47] The database provided no information about the quality of a view, which can greatly affect its value. Therefore, the view variable was interacted with other attributes of a property’s location, namely proximity to water bodies, to help capture the geographic variance in view quality.
[48] The parcel database was acquired from SanGIS.
[49] If a polygon (block or block group) fell only partially within a buffer, then data was aggregated to the property in proportion with the share of polygon area that fell inside of the buffer.

effect on property values (such as a highway), a series of dummy variables were created which measure proximity to the feature in 500 foot intervals.

- *Neighborhood Dummy Variables* – Despite the large set of neighborhood characteristics that were calculated (as described above), these variables still cannot fully capture the uniqueness of each neighborhood. Consequently, a set neighborhood dummy variables were created to capture the value of unmeasured factors within a neighborhood. This meant establishing a set of appropriate neighborhood boundaries. For the purposes of this research, it was necessary to define neighborhoods where rail distance varied significantly *within* neighborhood boundaries. Otherwise, the effect of rail proximity on property values would be captured within the neighborhood dummy coefficients where it could not be distinguished from the effect of other neighborhood factors[50]. Assigning each property to a "neighborhood" based on the closest rail station[51] provided a simple and effective approach to neighborhood definition. This allowed for significant variation in rail distance within neighborhoods while still creating fairly compact neighborhoods areas[52]. After implementing the above defined neighborhood structure, condominiums were divided into 35 different neighborhoods and single family homes into 40 neighborhoods.

[50] Census block groups and census tracks were initially tested as the basis for the neighborhood dummies but did not provide the necessary variance in rail distance and resulted in insignificant rail distance coefficients.
[51] The process of defining neighborhoods by the closest station is roughly equivalent to creating Thiessen polygons around each station, except network distance was used instead of Euclidian distance.
[52] Because the study area is limited to properties within 1 mile of a station, any given "neighborhood" will have a radius no larger than one network mile.

- *Jurisdictional Characteristics* - The taxes, regulations, and quality of services (e.g., schools, fire, police, and trash) within a given jurisdiction can have a strong effect on property values. A series of municipal dummy variables was created to capture these effects but they became redundant and unnecessary when the models included the previously described neighborhood dummies, which mostly nested within municipalities. There were a few cases where a neighborhood boundary overlapped with a municipal boundary and in such cases the appropriate municipal dummy was included. In addition to the municipal dummy variables, some more specific jurisdictional characteristics, such as property tax rates[53] and local school test scores[54], were also tested as independent variables[55]. However, these characteristics were largely captured within the neighborhood dummy variables so that these variables were found insignificant in all models. Zoning information is the final jurisdictional element that was evaluated for this analysis. Zoning provides the key element of the analysis presented in Chapter 5. Therefore, the zoning variables used in the analysis will receive a detailed treatment in that chapter.
- *Rail Proximity* - Station proximity was measured as network (walking) distance to the nearest station. Many functional forms were tested for this variable. A logarithmic transformation was empirically determined to provide the best fit. It

[53] The Metroscan database provided the tax rate area and the corresponding tax rates were available on the San Diego County Assessor's web page.
[54] Attendance boundaries for elementary, middle schools, and high schools were obtained from all school districts in the study area. The "Academic Performance Index" (API) score provided by the California Department of Education was then linked to these attendance boundaries. Each property was then assigned the relevant attendance boundary and assigned the corresponding API score.
[55] These variables were tested both in simple OLS regression and as endogenous variables in 2-stage least squares regression.

also makes theoretical sense, as a logarithmic transformation effectively represents the flattening of the price curve beyond walking distance. Proximity to the rail right-of-way (ROW) was also tested as a way to capture the negative effect of rail on property value due to noise, vibration, and safety concerns. Separate variables were calculated for properties near a ROW with light rail only versus a ROW that accommodates diesel engines (commuter rail and freight trains). However these variables were not significant predictors of property values[56].

- *Regional Characteristics* - Several variables that measure proximity/access to various regional locations and facilities were calculated for this analysis. Some of these measures included a gravity based employment accessibility index, distance (in network miles and minutes) to the CBD, distance to the beach/ocean, distance to the nearest freeway interchange, distance to the nearest shopping center, and distance to the Mexican border. However, the neighborhood dummy variables have a geographic component that largely captures these regional characteristics. Therefore these variables rarely proved significant or necessary[57].

3.5 Variable Descriptions and Summary Statistics

Table 3.1 below provides a detailed description for all variables that actually were used in at least one of the subsequent models. In the interest of organization and space, the abbreviated variable names in the left hand column will be used in all subsequent tables.

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[56] Proximity to the diesel rail tracks was found to be a significant predictor of allowable unit density and was therefore used as an instrument in the 2SLS models in Chapter 5.

[57] The exception is the model in Chapter 6 where distance to the CBD (by rail and auto) was interacted with station proximity.

Table 3.1. Variable Descriptions

Variable	Description	Data Source[58]
DEPENDENT VARIABLE		
price_00	Amount (US $) for which the property was most recently sold. Dollar values are adjusted to the first quarter of 2000.	Metroscan
RAIL PROXIMITY[59]		
rail_dis	Network miles to the nearest rail station.	MTS rail station layer, SANGIS 2002 road network[60]
ZONING VARIABLES		
units_z1	Allowable units per acre as defined in the applicable zoning code	various[61]
units_z2	Allowable units on a parcel. This is the product of the number of allowable units per acre (**units_z1**) and the number of acres on a lot (**lot_acre**).	see **units_z1** & **lot_acre**
PROPERTY CHARACTERISTICS		
str_sqft	Square feet of floor space in the unit.	Metroscan
lot_acre	Number of acres on the parcel's lot per unit on the parcel[62].	SANGIS 2002 parcel layer
str_age	Age of the structure (in years) at the time of the sales transaction.	Metroscan
baths	Number of bathrooms in the unit.	Metroscan
beds	Number of bedrooms in the unit.	Metroscan
garages	Number of garage spaces attached or assigned to a unit.	Metroscan
slope_p	Average slope (rise/run) within the parcel boundary.	SANDAG 10 meter elevation grid
view	Unit has a view (0-1).	Metroscan
pool	Unit or complex has a pool (0-1).	Metroscan

[58] This is the underlying data source. Many of these variables required further manipulation (mostly using GIS), which was done by the author after receiving the data from the original source.
[59] The rail distance variable technically should be grouped with the other variables in the "regional characteristics" category. However, since this is the key variable for this research, it has been given its own grouping.
[60] Off-road pedestrian paths in the areas immediately around rail stations were manually added to the road network based on in-person exploration of each station area.
[61] Some zoning information was obtained from Metroscan and some from the various municipalities in the region.
[62] For single family properties the lot acres and the lot acres per unit will be the same.

Table 3.1. Variable Descriptions (continued)

Variable	Description	Data Source
NEIGHBORHOOD CHARACTERISICS		
res_land	Proportion of area within ¼ mile of the parcel dedicated to residential use.	SANDAG 2000 land use layer
hunits_g	Gross housing units per acre within ¼ mile of the parcel.	2000 US Census, by block
hunits_n	Net housing units per acre within ¼ mile of the parcel. This is the gross housing units per acre (**hunits_g**) divided by the proportion of residential land (**res_land**)[63].	see **hunits_g** & **res_land**
prewar	Proportion of housing units built before 1940 within ¼ mile of parcel.	2000 US Census, by block group
all_emp	Total employment per acre within ¼ mile of parcel.	2000 US Census, by block group
fd_emp	Employment per acre in both food occupations and art/entertainment industry within ¼ mile of parcel.	2000 US Census, by block group
ae_emp	Employment per acre in both art/entertainment occupations and art/entertainment industry within ¼ mile of parcel.	2000 US Census, by block group
pr_emp	Employment per acre in production occupations within ¼ mile of parcel.	2000 US Census, by block group
intrsctn	Number of street intersections per land acre within ¼ mile of parcel.	SANGIS 2002 street layer
park_lot	Proportion of area within ¼ mile of the parcel dedicated to a park-and-ride lot.	SANDAG 2000 land use layer
beach_a	Proportion of area within ¼ mile of the parcel dedicated to an active[64] beach.	SANDAG 2000 land use layer
beach_p	Proportion of area within ¼ mile of the parcel dedicated to passive[65] beach.	SANDAG 2000 land use layer
open_spc	Proportion of area within ¼ mile of the parcel dedicated to permanent open space and/or wildlife and nature preserves.	SANDAG 2000 land use layer
agr_land	Proportion of area within ¼ mile of the parcel dedicated agricultural land.	SANDAG 2000 land use layer
ocean	Proportion of area within ¼ mile of the parcel that is ocean.	SANDAG 2000 land use layer
lagoon	Proportion of area within ¼ mile of the parcel that is lagoon.	SANDAG 2000 land use layer
slope_n	Average slope (rise/run) within ¼ mile of the parcel.	SANDAG 10 meter elevation grid
hwy_500	property is within 500 feet of a grade separated road (0-1)	SANGIS 2002 street layer
hwy_1k	property is between 500 & 1,000 feet of a grade separated road (0-1)	SANGIS 2002 street layer
bus_500	property is within 500 feet of a bus route (0-1)	MTS bus route layer
bus_1k	property is between 500 & 1,000 feet of a bus route (0-1)	MTS transit route layer
trkd_500	property is within 500 feet of a diesel rail tracks (0-1)	MTS transit route layer

[63] If **res_land**, **hunits_g**, and **hunits_n** are used together in a model, **hunits_g** becomes an interaction term for **res_land** and **hunits_n**.
[64] Active beaches are defined as being easily accessible with parking, lifeguards, and other public services.
[65] Passive beaches are poorly accessible (usually below cliffs) without public services.

Table 3.1. Variable Descriptions (continued)

Variable	Description	Data Source
REGIONAL CHARACTERISITCS		
dt_auto	Minutes to the San Diego CBD[66] by auto (morning peak).	SANDAG 2000 travel model skims
dt_rail	Minutes to the San Diego CBD by rail[67] (morning peak).	MTS frequencies and travel times
dt_ratio	The ratio of minutes to the CBD by auto and rail. This is calculated as **dt_auto/dt_rail**[68].	see **dt_auto** & **dt_rail**
stfr_tt	Minutes to the nearest storefront commercial cluster by auto (off-peak).	SANDAG 2000 land use layer, SANDAG 2000 travel model skims
slope_r	The absolute value of the slope (rise/run) between the parcel and the nearest rail station.	SANDAG 10 meter elevation grid, MTS rail station layer, SANGIS 2002 road network
coaster	The nearest rail station is a commuter rail station (0-1).	MTS rail station layer, SANGIS 2002 road network
headway	Time between trains and the nearest rail station during the peak period	MTS frequencies

Table 3.2 provides summary statistics (stratified by condominiums and single family homes) for the variables just described in Table 3.1. For dummy variables (marked with an asterisk), the mean represents the percentage of observations that fall in that particular category.

[66] The center of the CBD is defined as Horton Plaza.
[67] Rail travel times were calculated using the following assumptions:
line-haul time = published timetables
wait time = published peak headway/3
walk access time = network miles to station (**rail_dis**)* 20 (assumes a 3 mph walk speed)
walk egress time = 2.5 minutes
[68] If **dt_auto**, **dt_rail**, and **dt_dif** are used together in a model, **dt_auto** becomes an interaction term for **dt_rail** and **dt_dif**.

Table 3.2. Variable Summary Statistics

	Single Family N = 4,970		Condominium N = 4,166		Combined N = 9,136	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
DEPENDENT VARIABLE						
price_00	$212,994	$126,905	$176,663	$132,095	$196,427	$130,551
RAIL PROXIMITY						
rail_dis	0.70	0.22	0.62	0.23	0.66	0.23
ZONING VARIABLES[69]						
units_z1	10.53	7.13	22.77	10.78	13.65	9.80
units_z2	1.66	1.16	1.08	0.65	1.51	1.08
PROPERTY CHARACTERISTICS						
str_sqft	1,323	431	1,064	365	1,205	422
lot_acre	0.17	0.10	0.05	0.03	0.12	0.10
str_age	41.45	19.53	18.43	7.86	30.95	19.16
baths	1.69	0.62	1.74	0.57	1.71	0.60
beds	2.88	0.72	1.96	0.75	2.46	0.87
garages	1.41	0.76	0.62	0.81	1.05	0.88
slope_p	0.044	0.038	0.044	0.044	0.044	0.041
view*	0.187		0.186		0.186	
pool*	0.071		0.102		0.085	

[69] The N for the zoning variables is 4,868 for single family properties and only 1,670 for condominiums because of missing values.

Table 3.2. Variable Summary Statistics (continued)

	Single Family N = 4,970		Condominium N = 4,166		Combined N = 9,136	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
NEIGHBORHOOD CHARACTERISICS						
res_land	0.530	0.152	0.341	0.147	0.444	0.177
hunits_g	4.50	1.83	5.84	2.47	5.11	2.25
hunits_n	9.27	4.80	19.11	8.19	13.76	8.19
prewar	0.077	0.097	0.037	0.070	0.059	0.088
all_emp	3.41	3.17	7.40	5.12	5.23	4.62
fd_emp	0.150	0.203	0.453	0.443	0.288	0.367
ae_emp	0.009	0.023	0.030	0.029	0.018	0.028
pr_emp	0.162	0.249	0.247	0.200	0.201	0.232
intrsctn	0.250	0.121	0.177	0.125	0.217	0.128
park_lot	0.004	0.009	0.004	0.009	0.004	0.009
beach_a	0.001	0.009	0.006	0.020	0.003	0.016
beach_p	0.001	0.005	0.001	0.007	0.001	0.006
open_spc	0.018	0.048	0.044	0.061	0.030	0.056
agr_land	0.001	0.008	0.001	0.005	0.001	0.007
ocean	0.008	0.048	0.046	0.117	0.025	0.089
lagoon	0.001	0.017	0.005	0.042	0.003	0.031
slope_n	0.044	0.024	0.043	0.025	0.044	0.024
hwy_500*	0.130		0.244		0.182	
hwy_1k*	0.129		0.241		0.180	
bus_500*	0.420		0.825		0.605	
bus_1k*	0.322		0.125		0.232	
trkd_500*	0.026		0.054		0.038	
REGIONAL CHARACTERISITCS						
dt_auto	24.90	13.74	26.01	15.80	25.41	14.73
dt_rail	53.81	16.00	52.57	18.52	53.24	17.20
dt_ratio	0.442	0.116	0.467	0.123	0.453	0.120
stfr_tt	3.00	0.81	2.94	0.78	2.97	0.80
slope_r	0.018	0.015	0.012	0.014	0.015	0.015
coaster*	0.131		0.212		0.168	

The previous tables do not display the neighborhood and jurisdictional dummy variables. These variables will be of interest only to those very familiar with the San Diego region. Their summary statistics will be placed in Appendix A for the interested reader. The model coefficients for these variables will also be left off of subsequent tables and presented in Appendix A.

Chapter 4. Comparing Rail Transit Capitalization for Condominiums and Single Family Homes

4.1 Transit Capitalization and Property Type

Understanding which property types gain the greatest benefits from rail transit proximity can prove extremely useful to station area planning. Obviously, if a certain property type receives greater capitalization benefits, it will likely prove beneficial to actively recruit and zone so that such properties are built near stations. While it would be informative to empirically examine all property types, this chapter will focus on condominiums and single family homes. A separate hedonic price model was estimated for each of these housing types. To keep this analysis as straightforward as possible, these models will assess the *average* level of transit capitalization provided to the two property types. Consequently, although interactive terms will be a key element in later chapters, they are not needed here. To the degree possible, the specifications of the two models were kept the same to increase the validity of comparison. The comparison of these model findings created a de facto test of how high versus low density housing[70] condition transit capitalization. The fact that this comparison only includes condominiums rather than all multi-family housing mostly controls for the large income and class disparities that might otherwise distinguish between occupants of single and multi-family housing. Before presenting the model results, there will be a theoretical examination of why capitalization benefits may

[70] It should be noted that certain condominium complexes have extensive grounds and recreation areas. If such areas are included in the density calculation, they may actually have lower densities than some single family neighborhoods (especially older ones).

differ by property type. This should prove useful in interpreting and understanding the empirical evidence.

At first thought, higher density development seems most congruent with close station proximity. Several planning concepts[71] promote the idea of dense transit nodes to increase transit ridership, reduce reliance on automobiles, and curb urban sprawl (Bernick & Cervero 1997, Calthrope 1993). In terms of the research at hand, condominiums usually fit better into this vision of transit-oriented development (TOD) than single family homes. Consequently, one might intuitively expect condominiums to receive greater capitalization benefits. However, despite the conceptual attractiveness of TOD to urban planners, this does not necessarily mean the general public shares this view or that it will have any impact on property markets.

4.2 Property Market Segments

Market segmentation presents a more practical way to look at potential differences in capitalization by property type. People on the market for various property types can be divided into segments and analyzed by socio-demographic characteristics and attitudes. The various segments can then be compared to characteristics of those who would likely value good transit access (i.e., the transit-friendly characteristics discussed in Chapter 2 (section 2.2)). The market segment with a profile that more closely resembles a transit user[72] will likely generate the kind of bidding that leads to transit capitalization benefits. The condominium market

[71] The idea of high density and pedestrian friendly transit nodes might fall under the rubric of transit villages, transit-oriented development, new urbanism, or neo-tradition design.
[72] For non-residential properties, it is not the buyer that should fit the transit user profile but, rather, the customers and employees.

intuitively fits the transit user profile (smaller household, preferences for urban living) better than the single family market.

The Public-Use Microdata Sample (PUMS) from the 2000 US Census provides disaggregate demographic data, including housing type, for a large sample of households for all regions in the US. This data allows for a comparison of the demographic attributes of households in owner-occupied[73] condominiums and single family homes within the study area[74]. Unfortunately, the PUMS does not provide information about attitudes and lifestyle preferences, which can also provide a good indication about transit usage. Table 4.1 below provides a demographic summary by housing type.

Table 4.1. Demographic Summary of Households by Property Type

	Condominium	Single Family
# of households (in 000's)	59.2	248.8
% located in central city[75]	14.6	8.8
mean household income (in 000's)	60.9	81.7
mean household size	2.1	3.0
% with single occupant	39.2	15.6
% with children (< 18)	22.1	38.6
% with all elderly occupants (> 65)	21.5	17.7
% with all disabled occupants	3.5	2.9
mean vehicles per adult	0.9	1.1
% with 0 vehicles	4.2	3.3
% commute by transit[76]	2.8	2.3

[73] Some condominiums will be occupied by renters but the census data does not distinguish whether household is renting a condo or a multi-family unit that is not condo. Therefore, only owner-occupied units are analyzed in Table 4.1.
[74] PUMS data is provided in a large geographic unit called a PUMA. The San Diego MSA has 16 PUMAs, 10 of which fall within the study area. Data from these 10 PUMAs were used to generate the statistics in Table 4.1.
[75] The central city is defined as the PUMA in which downtown San Diego is located. It actually covers a much larger area than just downtown.
[76] The denominator in this measure is workers (not households).

For almost all of the categories presented in Table 4.1, the profile of those living in condominiums fits more closely with what one would expect from a transit user (e.g., smaller households, older households, fewer children, lower incomes, and fewer cars), albeit the differences are sometimes small. As suggested earlier, the fact that condominiums are owner-occupied minimizes the demographic differences that would otherwise be found between the occupants of multi-family and single-family housing. In terms of actual transit usage, those living in condominiums only have a slightly higher commute mode share (the census does not provide data about non-work travel). However, because these mode shares are averages for a large geographic area (much of which has poor, if any, transit service), they may not indicate the true value placed on transit by the typical occupant of these property types. An analysis of only well served transit locations, which the PUMS unfortunately does not permit, might show a much greater difference in transit mode choice[77]. Given the differences presented in Table 4.1, one can infer that the condominium market segment has some additional share of potential buyers interested in station area housing. However, when considering the larger overall size of the single family market, a small share of this market could equal or even surpass the condo market in overall demand for station area housing.

[77] Areas without transit service will have no transit riders even if the demographic attributes would indicate otherwise. If enough condominiums are located in these areas poorly served by transit, it will mute the difference in transit mode shares between the condo and single family market segments.

Station Area Housing Supply

In analyzing the potential for capitalization benefits, an accounting must also be made for the supply of a given property type. If the supply of a property type is limited near stations, then modest demand can still create premiums. Table 4.2 provides a summary of the supply of condominiums and single family units within certain distances of a rail station in the San Diego MSA during 2001[78].

Table 4.2. Supply of Housing Units by Property Type and Distance from a Rail Station

	Condominiums	Single Family Homes
Total in MSA	143,960	515,440
Within ¼ mile	5,384 (3.7%)	1,249 (0.2%)
Between ¼ and ½ mile	4,526 (3.1%)	6,015 (1.2%)
Between ½ and ¾ mile	4,535 (3.2%)	11,112 (2.2%)
Between ¾ and 1 mile	4,360 (3.0%)	14,366 (2.8%)
> 1 mile	125,155 (87.0%)	482,698 (93.6%)

For areas within ¼ mile of a station, the supply of condos is more than four times greater than single family units. If considering properties within ½ mile, the supply of condos is still 30 percent greater. This indicates that if condos gain more benefits from rail proximity than single family properties, it cannot be due to condominium supply constraints. For both property types, units near a station make up a very limited portion of the total supply, lending credence to the assertion in Chapter 2 (section 2.2) that the supply of housing near stations is extremely limited.

As a final note on property market segments, one should consider that market segments simplify reality. While many home buyers likely enter the market with a

[78] These unit counts come from a 2001 GIS parcel database provided by SanGIS.

clear preference for a condo or single family unit, others may put a higher priority on location without as much consideration of property type. If a significant portion of those looking for a property near a station take the latter approach, it will mute the variation in capitalization benefits by property type.

4.3 Single Family and Condominium Model Findings

Table 4.3 presents the coefficients, standard errors, and probability statistics for the condominium and single family price models, which exclude the station distance interactions used in later chapters. The variable descriptions and summary statistics were previously presented in Chapter 3 (Tables 3.1 and 3.2).

Table 4.3. Condominium and Single Family Price Model Comparison

	OLS Estimation with Heteroskedastic-Robust Standard Errors					
	Model 4.A,Dependent Variable: Single Family Unit Sales Price			Model 4.B, Dependent Variable: Condominium Unit Sales Price		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
RAIL PROXIMITY						
ln(rail_dis)	-8,512.11	3,118.81	0.006	-16,195.61	2,331.95	0.000
PROPERTY CHARACTERISTICS						
str_sqft	71.64	3.33	0.000	183.42	15.20	0.000
lot_acre	19,070.74	11,941.91	0.110	319,649.79	70,805.84	0.000
lot_acre*all_emp	16,216.36	3,310.35	0.000			
str_age	-249.15	59.17	0.000	-4,444.61	762.32	0.000
str_age^2				70.57	20.36	0.001
baths	8,838.24	2,061.07	0.000	-8,442.54	3,785.46	0.026
beds				-12,275.19	4,060.18	0.003
garages	7,851.65	1,117.88	0.000			
slope_p	-645.99	335.91	0.055			
view	10,967.41	2,116.39	0.000	7,711.91	2,008.60	0.000
view*coaster	25,558.38	10,202.67	0.012	25,867.97	10,270.89	0.012
view*ocean	746,040.54	150,895.76	0.000	322,879.30	47,959.61	0.000
view*lagoon	901,105.28	247,345.91	0.000			
pool	9,502.91	3,610.61	0.009			
NEIGHBORHOOD CHARACTERISICS						
res_land	32,854.80	15,643.34	0.036	-23,745.54	17,741.45	0.181
hunits_g	-3,034.98	1,621.60	0.061			
hunits_n	-528.02	757.60	0.486	-1,377.48	384.20	0.000
prewar	229,688.58	36,761.65	0.000	129,750.12	34,180.97	0.000
all_emp	-1,292.17	932.08	0.166			
fd_emp				28,093.13	5,993.49	0.000
pr_emp	-20,179.68	4,653.28	0.000	-30,585.24	9,253.25	0.001
intrsctn	44,870.88	15,889.53	0.005			
park_lot	-391,334.26	139,315.22	0.005			
beach_p	1,565,243.41	775,191.18	0.044	513,135.31	314,183.03	0.103
open_spc	113,489.69	20,705.00	0.000			
agr_land	460,329.00	281,978.73	0.103			
ocean	237,270.25	83,115.26	0.004	206,278.86	36,797.47	0.000
lagoon	87,683.74	110,309.74	0.427			
hwy_500	-8,399.97	2,867.94	0.003	-8,947.27	3,336.32	0.007
hwy_1k	-3,017.53	2,263.17	0.183	-7,606.58	3,315.85	0.022
bus_500	-7,992.96	1,926.44	0.000	-9,581.27	4,246.85	0.024
bus_1k	-2,588.61	1,842.89	0.160			
constant	-32,777.77	16,506.40	0.047	-226,418.74	38,493.28	0.000
	N = 4970 F=170.7879, P = 0.000 R^2= 0.8664			N = 4166 F=257.456, P = 0.000 R^2= 0.8332		

With an R^2 of greater than 0.8, both presented models have a strong overall fit. Most of the variables have significant and intuitive coefficients. Several variables that were significant predictors of single family home prices were not for condominiums and were excluded from the condominium model. It seems that condo prices are not as sensitive to certain amenities (e.g., open space) and disamenities (e.g., freeways). These models conspicuously lack any controls for neighborhood income or social class. Several variables of this sort[79] were tested but the neighborhood dummy variables (presented in Appendix A) captured much of their effect and rendered them insignificant[80]. These variables were also left out of models in subsequent chapters for the same reason.

For the condominium model, the rail distance variable has a very strong negative coefficient (significant at .000, t = -6. 9) [81], meaning that condo prices significantly decrease with distance from a rail station. The results also indicate that single family prices significantly decrease with station distance but not at the same rate. The rail distance coefficient in the single family model is roughly half the size of the same coefficient in the condo model and has a larger standard error (significant at .006, t = -2.7). Figure 4.1 illustrates the estimated value that rail proximity adds to the price of single family and condominium unit (note that this chart does not present the

[79] Socio-economic variables (all measured within ¼ mile of the property) that were tested include mean household income, per capita income, share of population with at least a bachelor's degree, share of population with an advanced degree, percent of the population that is white, and percent of the population that speaks Spanish only.
[80] Some of these variables were moderately significant when treated as exogenous. However, these socio-economic variables are very likely endogenous to property values. When treated endogenously in a 2-stage least squares model, none of these variables were significant. This was the case even after experimenting with numerous instruments. Whether treated endogenously or exogenously, the inclusion of these variables had very little impact on the rail distance coefficient.
[81] The t statistic is the coefficient/standard error. The absolute value of this statistic provides a better way to compare the strength of two highly significant coefficients than comparing significance levels.

total value of a unit but only the additional value that rail proximity adds to a unit, all other things equal).

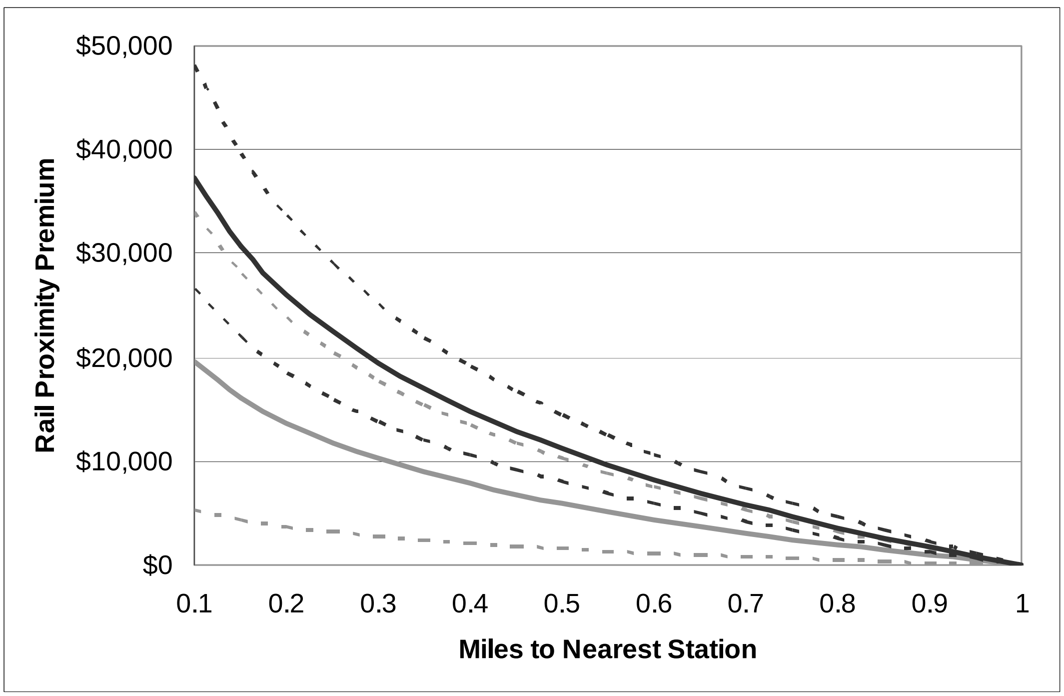
Figure 4.1. Price Premium Associated with Rail Proximity for Single Family and Condominium Units[82]

Black = Condo

Grey = Single Family

Solid Line = Model Estimate

Dashed Line = 95% Confidence Interval



To the degree that the presented models are well specified, station proximity clearly has a much greater impact on condominiums (at least on average). A condominium

[82] The x-axis of the chart begins at 0.1 instead of 0 because only a handful of properties in the database (< 10) were closer than 0.1 miles from a station.

that is ¼ of a mile from a station is worth just over $20,000 more than one that is 1 mile from the station (all else equal). A single family home ¼ mile from a station is only worth $10,000 more. The premium percentage will obviously depend on the total value of the property, which will differ depending on location and structure characteristics. The base value for condos will usually be smaller than the base value for a single family home. Therefore, in percent terms, the premium size will favor condos even more than in terms of raw dollar values. These results indicate that some synergy exists between those on the market condo units and those interested in good station access.

Determining the underlying driver of the condo/station synergy requires more exploration. A preference for urban living was earlier suggested as a potential commonality of transit-friendly and condominium markets segments. If this preference truly drives the synergy between condos and transit, then the property type in and of itself does not necessarily matter. A single family home in an urban environment might receive transit capitalization benefits more similar to what is shown for condos. The presented models do little to test for this because the difference in the average premiums for the two property types implicitly reflects their average neighborhood characteristics. The location for single family homes are usually less "urban" as evidenced in the comparison of neighborhood characteristics for the two property types previously presented in Table 3.2. For example, in the database used for these models, the gross density of employment within a quarter mile of the parcel averaged 7.4 jobs/acre for condos while it was only 3.4 jobs/acre for single family units. The residential density (also within ¼ mile) was 19.1 net and 5.8 gross units/acre for condos and 9.2 net and 4.5 gross units/acre for single family properties. Further work in this area would help to determine whether condominiums receive greater capitalization benefits because of the property characteristics or the implicit neighborhood type. However, this will be extremely difficult because in most regions, San Diego included, very few single family homes exist in neighborhood with truly “urban” characteristics[83].

[83] In such situations, the statistical analysis must extrapolate based on the limited variation within the dataset. This does not provide reliable estimates.

Chapter 5. Zoning and Rail Transit Capitalization

The analysis presented in this chapter incorporates zoning in its measurement of transit capitalization benefits. The previous analysis provided some indication that greater transit capitalization benefits accrue to higher density housing. In order to have higher density development, the zoning regulations must permit such development. At the same time, if zoning does not permit higher densities around stations it may well limit the potential for rail to increase property values. The interaction of zoning variables with rail proximity will help elucidate the way zoning conditions the impact of rail stations. The subsequent analysis will test the hypothesis that zoning significantly conditions rail transit capitalization benefits.

5.1 Purpose of Zoning

Zoning ordinances allow local governments to dictate the type and intensity of development that can occur at a given location. By separating incompatible uses, prohibiting undesirable development, and/or prescribing desirable development, zoning theoretically promotes the safety and welfare of the population. At the same time, zoning regulations limit the development rights of a property owner and can exclude certain segments of the population. Up through the early part of the 20th century, US cities had very limited zoning regulations due to concerns of constitutionality (Mills 1979). In 1924, the US Supreme Court deemed the local regulation of land use as a constitutionally legitimate use of police powers in that it serves the public interest. Most cities have since implemented some sort of zoning program.

The different types of zoning categories used today are numerous and complex but zoning regulations can be broken down into three broad categories (O'Sullivan 1996, Ch.11):

- Nuisance Zoning – Certain land uses generate negative side effects that might be considered a neighborhood nuisance. For example, industrial activities can cause pollution, retail activities can cause noise and traffic congestion, and tall buildings can block views and light. Cities might create zoning ordinances that either completely shut out nuisances or put nuisance generating uses in special zones to limit the spatial extent of side effects (Moore 1978).
- Fiscal Zoning – This type of zoning seeks to exclude properties (especially residential units) that do not pay their fair share of costs. Since local governments rely on property taxes for revenue, smaller or less expensive properties will often contribute less to a city's revenue base than the services they receive (Fischel 2004). Using ordinances that require properties (especially housing) to be of a certain size prevents free riders. The legitimacy of fiscal zoning is often questioned because there is only a small distinction between keeping out free-riders and illegally excluding poor and minorities.
- Design Zoning – This type of zoning might be considered "macroarchitecture". Planners can arrange land uses in a way that makes efficient use of a city's infrastructure. For example, zoning that encourages transit-oriented development around rail stations can maximize the usage of the rail service.

5.2 The Effect of Zoning on Property Values

The way in which zoning affects property values can be very complicated (Pogodzinski & Sass 1990, Dowall 1981, Grieson & White 1981). Nuisance zoning will positively impact property values by prohibiting undesirable uses. For example, zoning for large detached residential units may raise the price of residential property because such restrictions prevent higher density housing or commercial uses from bringing traffic, bustle, and possibly crime. Design zoning can positively influence prices by prescribing desirable uses such as parks and open space. Fiscal zoning can help keep property tax rates low and these lower tax rates are then positively capitalized into property values. Zoning can also increase property values by limiting supply of a given property type.

Conversely, by limiting the size and type of the structure a landowner can build on her/his property, zoning can have a negative impact on the value of a property. As land becomes more expensive, developers usually respond by decreasing the amount of land per unit of building space (O'Sullivan 1996, Ch. 8). In other words, it is more economically efficient (from the landowners perspective) for high priced land to be developed at high densities. Further, certain types of uses can generate greater revenues. For example, the tenants of office buildings generally require high levels of accessibility and will pay high rents for locations in the central business district and other commercial centers. Consequently, if zoning limits the density of development or prohibits certain uses, it may also limit what developers will bid for that land.

The net effect of zoning on property values probably depends on the type of use the market would dictate in the absence of zoning. For example, density restrictions will not adversely affect cheap land near the urban fringe because the market would dictate low density uses anyway. However, when the market dictates higher densities, zoning restrictions will more likely create a net negative impact. As the gap widens between the uses prescribed by a zoning ordinance and the market determined "highest and best" use, zoning will more likely have a net negative effect on the value of a property.

The empirical evidence generally shows that more restrictively zoned areas have lower property values. In terms of the theory discussed in the previous section, this means that the negative effect of restricting a property owner's development choices often outweigh the various positive influences. Studies consistently show that areas zoned for high densities (loose height restrictions, lower minimum lot sizes) have higher property values (Knaap 1998, Pogodzinski and Sass 1991a, Pogodzinski and Sass 1991b). Studies about allowable use zoning have more mixed results. Some studies demonstrate higher property values in commercial and multi-family zones (Wallace 1998, Crone 1983) while others show that single family residential land does not significantly differ from other areas (Maser et al. 1977).

5.3 Zoning around Rail Stations

Cities often create permissive and mixed-use zoning policies and other incentives to draw development and, more specifically, TOD around rail stations (Vessali 1996). In fact, supportive land use policies might be a necessary condition for transit to have a significant impact on station area development (Knight & Trygg 1977). The ability of rail transit investment to spur communities and policy makers to accept more lenient zoning policies may have a greater impact on property values than the actual presence of rail.

Municipalities do not always implement transit supportive zoning policies around stations. Boarnet & Crane (2001) found that communities in southern California put a heavy focus on commercial zoning for tax revenue purposes. This may be appropriate at a few “destination” stations but too many stations zoned only for commercial development creates an imbalance that does not bode well maximizing patronage. Further, while commercial development is a key component of TOD, creating vibrant walkable environment to complement rail proximity requires a mixing of residential and commercial uses (Ewing 1997, Bernick & Cervero 1997).

At the other extreme, local residents sometimes oppose increased development densities and force downzoning to protect the existing character of their neighborhoods (Cervero & Landis 1997, Giuliano 1995). This is often done in the name of preserving home values but it may also mute rail transit capitalization. If a rail station provides enough accessibility, the demand for a property (and the corresponding price) can rise to a point where higher densities or a “higher” use becomes appropriate. If zoning prevents redevelopment or densification, the price of the property will not increase as much as the accessibility improvement would otherwise dictate.

5.4 Measuring the Impact of Zoning on Transit Capitalization

Most studies of transit capitalization do little to disentangle the effects of policy and market forces (Cervero & Landis 1997). A handful of studies have attempted to implement simple controls for zoning. Not coincidentally most of these studies focus on Portland, OR, where zoning information is ostensibly easy to obtain[84]. Chen et al. (1998) and Al-Mosaind et al. (1993) both use a dummy variable for single family zoning and Lewis-Workman and Brod (1997) use an even simpler dummy variable that measures whether a property is zoned for any kind of residential use. They all find that restricting development to residential uses has a positive but small effect on home prices. However, because these studies treat zoning independently of transit proximity, there is no way to tell whether the restrictive zoning policy equally affects properties that are near or far from a rail station.

The empirical research presented in this chapter measures the interaction of station proximity with variables measuring zoning permissiveness. Zoning information was not fully available for condominiums[85]. Therefore, this analysis of zoning interactions will focus on single family properties. In the context of a single family unit, the zoning variable measures the value (positive or negative) of being able to redevelop a single family property to higher densities[86]. The interaction term with rail

[84] The county and regional agencies in the Portland Metropolitan were ahead of the curve in providing a GIS database with zoning information.

[85] Zoning information was obtained directly from the various municipalities in the study area except the City of San Diego, which did not maintain a digital zoning database. An independent source (Metroscan) provided zoning information within the city of San Diego but only for single family parcels and not for condominiums. Since condominiums within the city of San Diego made a majority of the observations in the database, it was decided to forgo the use of zoning variables in modeling condominiums.

[86] Property owners can often obtain a variance to build a development that does not meet existing zoning codes. Data measuring the potential to receive a variance was not readily available. However, it

distance will allow for a determination as to whether properties closer to a rail station benefit more from redevelopment potential.

5.5 Zoning Variables

Zoning Variable Description

Many zoning variables were gathered for this analysis[87]: maximum unit density, minimum lot size, height restrictions, floor area ratio (FAR), coverage area limits, setback requirements, and allowable use types. Most of these measures were not consistently used across the various municipalities in the study area. For example, some zoning ordinances don't have height restriction but instead use a floor area ratio to implicitly limit height. One variable that was consistently available[88] for all jurisdictions was unit density[89]. Therefore, the number of allowable units per acre was used as an independent variable in the ensuing models. In addition, this "units per acre" variable (**units_z1**) was interacted with lot size. This interaction measures the number of units allowed on a given lot (**units_z2**), which is much more relevant for measuring redevelopment potential than simply measuring the number of allowable

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is assumed that obtaining a variance involves enough risk and cost that zoning, on average, still has an effect on property values.

[87] An effort was made to try to obtain zoning regulations matching as closely to the time of sales transaction as possible but this was not always achieved. However, the zoning regulations used in the analysis were rarely more than 2 or 3 years removed from the property sale. Since zoning is treated endogenously, the bias associated with measurement error should have been eliminated (Kennedy 2003).

[88] A few of the observations were located in a "planned unit development" without a density limit for any specific parcel. These observations (roughly 100) were excluded from the models presented in this chapter.

[89] In the case of areas zoned for singe family units, the minimum lot size can be used to calculate the allowable units per acre.

units per acre[90]. Dummy variables for allowable uses (commercial, industrial, multi-family) were also tested but had little significance after allowable unit variables entered the model.

Endogenous Zoning

Property values are often a key determinant of how local jurisdictions choose to implement zoning regulations (Pogodzinski & Sass 1994). In other words, zoning and property values likely have an endogenous relationship. Municipalities generate revenue through property and sales taxes and allowing high intensity uses will often maximize tax revenue[91]. Therefore, the "highest and best use" as dictated by land prices surely enters into decisions about zoning policy. Several studies have shown that zoning does follow the market to a certain degree (Wallace 1988, McMillen & McDonald 1991). This endogenous relationship can create a bias in the hedonic price model. Consequently, the models presented in this chapter utilize a 2-stage least squares (2SLS) estimation with the zoning variables being treated as endogenous right hand side variables. Travel time to the nearest storefront commercial cluster (**stfr_tt**), average slope within ¼ mile of a parcel (**slope_n**), and proximity to rail tracks (**trkd_500**) were used as instruments. These instruments are similar to those used in previous work of a similar nature (Kahn 1997, Song & Knaap 2003, Pogodzinski and Sass 1994). Interaction terms with endogenous variables should also be considered endogenous (Wooldridge 2001 Ch. 9), meaning that the interactions with the zoning

[90] When a lot is small, it is more likely to already be at the density limit, even under a permissive zoning ordinance.
[91] The services required by high intensity uses will sometimes offset revenue, especially for multi-family housing.

variables and rail proximity must also be treated endogenously. In order to have enough instruments to treat the zoning variables *and* zoning/rail interactions endogenously, the previously listed instruments were interacted with lot size and rail proximity and the resulting interaction variables were then also used as instruments. Appendix B presents the results of the various first stage models and the statistical tests commonly associated with a 2-stage model (i.e., overidentification, Hausman, weak instruments)

5.6 Findings from Models with Zoning Variables

Table 5.1 below presents the coefficients, standard errors, and probability statistics for two models (Model 5.A and Model 5.B) predicting the price of single family homes. Model 5.A introduces zoning variables as controls (without rail proximity interactions) to see if this significantly affects the rail proximity coefficient. Model 5.B further includes interactions with zoning and rail distance.

In addition to the zoning interactions, interactions between rail distance and some of the built environment variables were also tested. Parcels with more permissive zoning more likely reside in more “urban” neighborhoods. Therefore, these built form interactions were tested to assure that the zoning interactions were not acting as proxy for an interaction with a more urban environment. None of these built environment interactions came out significant or caused any perceptible change in the zoning interaction coefficients.

Table 5.1. Single Family Models with Endogenous Zoning Variables

	2SLS Estimation[92] with Heteroskedastic-Robust Standard Errors Dependent Variable: Single Family Unit Sales Price					
	Model 5.A: Without Zoning/Rail Interactions			Model 5.B: With Zoning/Rail Interactions		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
ENDOGENOUS ZONING VARIABLES						
units_z1	-1,636.12	1,181.16	0.166	-2,225.11	1,341.25	0.097
units_z1*ln(rail_dis)				-417.88	656.23	0.524
units_z2	-4,597.14	4,843.01	0.343	-8,631.54	5,374.31	0.108
units_z1*ln(rail_dis)				-5,559.78	3,465.55	0.109
RAIL PROXIMITY						
ln(rail_dis)	-8,897.34	2,760.71	0.001	5,504.88	8,285.20	0.506
PROPERTY CHARACTERISTICS						
str_sqft	73.13	3.53	0.000	72.27	3.61	0.000
lot_acre	86,290.22	61,139.06	0.158	114,088.30	64,140.59	0.075
lot_acre*slope_p	-7,762.82	3,402.35	0.023	-9,129.08	3,602.46	0.011
lot_acre*all_emp	9,268.59	3,675.40	0.012	7,929.53	3,811.89	0.038
lot_acre*prewar	405,622.90	212,087.40	0.056	347,343.90	209,027.70	0.097
str_age	-562.73	187.67	0.003	-565.25	191.59	0.003
str_age^2	3.41	2.07	0.099	3.67	2.12	0.084
baths	9,099.01	2,043.84	0.000	9,775.74	2,137.15	0.000
beds	-2,386.42	1,462.53	0.103	-2,383.34	1,477.71	0.107
garages	7,343.61	1,191.99	0.000	7,282.33	1,216.45	0.000
slope_p	692.66	678.28	0.307	1,032.71	721.53	0.152
view	11,816.37	2,101.75	0.000	11,794.76	2,121.14	0.000
view*coaster	25,679.86	9,766.86	0.009	26,960.12	10,009.84	0.007
view*ocean	658,118.00	138,462.30	0.000	689,065.20	140,080.30	0.000
view*lagoon	979,532.70	142,223.50	0.000	992,981.90	149,172.30	0.000
pool	10,152.02	3,380.54	0.003	9,959.97	3,403.14	0.003

[92] Relevant 2SLS statistics and the performance of instruments in the first stage models are presented in Appendix B.

Table 5.1. Single Family Models with Endogenous Zoning Variables (continued)

	Model 5.A: Without Zoning/Rail Interactions			Model 5.B: With Zoning/Rail Interactions		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
NEIGHBORHOOD CHARACTERISICS						
res_land	47,312.84	21,269.18	0.026	36,936.25	23,002.66	0.108
hunits_g	-5,527.09	2,376.10	0.020	-5,014.70	2,469.37	0.042
hunits_n	2,870.19	1,829.16	0.117	3,062.99	1,865.70	0.101
prewar	152,780.90	47,862.29	0.001	159,837.20	47,886.29	0.001
all_emp	-1,113.76	1,052.35	0.290	-1,160.30	1,065.58	0.276
fd_emp	17,081.14	10,835.04	0.115	24,894.01	12,151.89	0.041
pr_emp	-21,919.75	5,945.65	0.000	-24,613.76	6,397.37	0.000
intrsctn	45,610.57	15,094.25	0.003	50,878.98	15,680.42	0.001
park_lot	-321,447.80	152,946.40	0.036	-361,761.10	157,177.60	0.021
beach_p	1,175,347.00	732,777.00	0.109	1,232,848.00	737,352.40	0.095
open_spc	107,691.00	19,795.80	0.000	105,364.90	20,339.82	0.000
agr_land	411,484.10	227,808.20	0.071	358,187.60	232,014.40	0.123
ocean	277,490.60	86,567.08	0.001	279,102.40	88,496.15	0.002
lagoon	124,351.10	105,228.30	0.237	110,257.60	117,642.50	0.349
hwy_500	-6,912.89	2,755.76	0.012	-6,929.52	2,815.46	0.014
hwy_1k	-2,877.26	2,227.30	0.196	-3,176.53	2,273.17	0.162
bus_500	-9,587.40	2,086.72	0.000	-10,741.30	2,255.25	0.000
bus_1k	-5,623.81	2,276.27	0.013	-6,246.95	2,363.66	0.008
constant	-29,438.06	19,724.88	0.136	-22,109.39	20,797.64	0.288
N = 4868	F=167.91, P = 0.000 R^2= 0.8596			F=161.52, P = 0.000 R^2= 0.8549		

Both models have an R^2 of greater than 0.8. As with the previous chapter, most of the variables have significant and intuitive coefficients.

Estimated Effect of Rail Proximity with Zoning Controls

The first key finding from this set of models is that the introduction of zoning controls in Model 5.A does not appreciably change the size and significance of the rail distance coefficient relative to Model 4.A (in Chapter 4, Table 4.3), which is a similar[93] model other than it does not include zoning controls. Table 5.2 below provides a more detailed comparison of the rail distance coefficients in these two models.

Table 5.2. Comparison of Rail Distance Coefficient with and without Zoning Controls

	B	S.E.	T	SIG
Model 4.A without Zoning Controls	-8,512.11	3,118.81	-2.7292842	0.006
Model 5.A with zoning controls	-8,897.34	2,760.71	-3.2228467	0.001

If the increased property values near rail stations resulted from the permissive zoning policies often associated with station areas[94] rather than the actual value of the rail service, one would expect the introduction of zoning controls to weaken the coefficient for rail distance. In fact, the coefficient is not weakened at all, indicating that rail proximity, on average, has value independent of station area zoning policy.

In Model 5.A, the zoning variables themselves are negative but not statistically significant. This suggests that, on average, the aspects of permissive zoning that might lower property values (e.g., allowing potentially undesirable uses and increasing supply of station area properties) do not significantly outweigh the positive influences (e.g., providing the land owner more freedom).

[93] A few additional variables are included in Model 5.A that were excluded from Model 4.A because they were not significant in that model.
[94] The results of the first stage model show that rail proximity is, in fact, a significant predictor of allowable units per acre.

The Value of Rail Proximity Conditional upon Zoning

The changes between Model 5.A and Model 5.B illustrate something even more interesting. Adding the zoning/rail proximity interactions causes large changes in the rail proximity and zoning variables, indicating that zoning does condition the effect of rail proximity on home prices (and vice-versa). The interaction terms and the constitutive terms are not strongly significant but, as discussed in Chapter 3 (section 3.4), the model parameters can be misleading when dealing with interactions.

The rail distance variable (**ln(rail_dis)**), changes from being negative and significant in Model 5.A to being positive and not significant in Model 5.B. Since this variable becomes a constitutive term in Model 5.B, its coefficient should be interpreted as the true coefficient for rail distance only when the zoning variables are equal to 0 (in fact, the zoning variables never equal 0[95]). Because the zoning/rail distance interaction terms are negative, the rail distance coefficient becomes negative as zoning becomes more permissive. As will be further illustrated below, the rail distance coefficient also becomes statistically significant as zoning becomes more permissive.

The ability of zoning to condition the effect of rail proximity is strengthened when combined with a larger lot size, which provides greater potential for redevelopment at higher densities. This is evidenced by the fact that the interaction of rail distance with "allowable units per acre" (**units_z1**) is much weaker (and extremely insignificant) than the interaction with "allowable units on the parcel" (**units_z2**), which is the interaction of **units_z1** and lot acres (**lot_acre**).

[95] No single family homes were located in areas where the zoning code did not permit at least low-density residential development.

Table 5.3 shows estimated coefficients for **ln(rail_dis)** at different levels of zoning permissiveness, along with the associated standard errors (calculated in the appropriate manner for interaction terms, as described in Chapter 3, section 3.4), and test statistics. The table assumes a lot size of 0.17 acres, which is average size for single family units in the model database. One would expect the pattern to be more exaggerated than what is presented below if a larger lot size was assumed for the calculations.

Table 5.3. Rail Distance (ln(rail_dis)) Coefficients from Model 5.B, Conditional upon Zoning Permissiveness

Zoning Assumptions for 0.17 acre lot					
Units per Acre (units_z1)	Units on Lot (units_z2)	B	S.E.	T	SIG
0	**0**	5,504.88	15,170.65	0.66	0.509
5	**0.85**	-1,310.33	2,830.15	-0.27	0.787
10	**1.7**	-8,125.53	4,900.87	-2.87	0.004
15	**2.55**	-14,940.73	7,864.12	-3.29	0.001
20	**3.4**	-21,755.93	4,540.75	-2.77	0.006
25	**4.25**	-28,571.14	15,170.65	-2.49	0.013
30	**5.1**	-35,386.34	11,475.53	-2.33	0.020

The table clearly illustrates how the rail proximity coefficient becomes stronger with more permissive zoning.

Figure 5.1 below illustrates the estimated value rail proximity adds to a property, all else being equal, under two scenarios. In the first scenario, a property has permissive zoning and high redevelopment potential (5 allowable units). In the second scenario zoning is restrictive and there is no redevelopment potential (1 allowable unit). Again, the estimates in the figure assume a lot size of 0.17 acres.

Figure 5.1. Price Premium for Rail Proximity as Conditioned by Zoning

Black = 5 allowable units

Grey = 1 allowable units

Solid Line = Model Estimate

Dashed Line = 95% Confidence Interval[96]

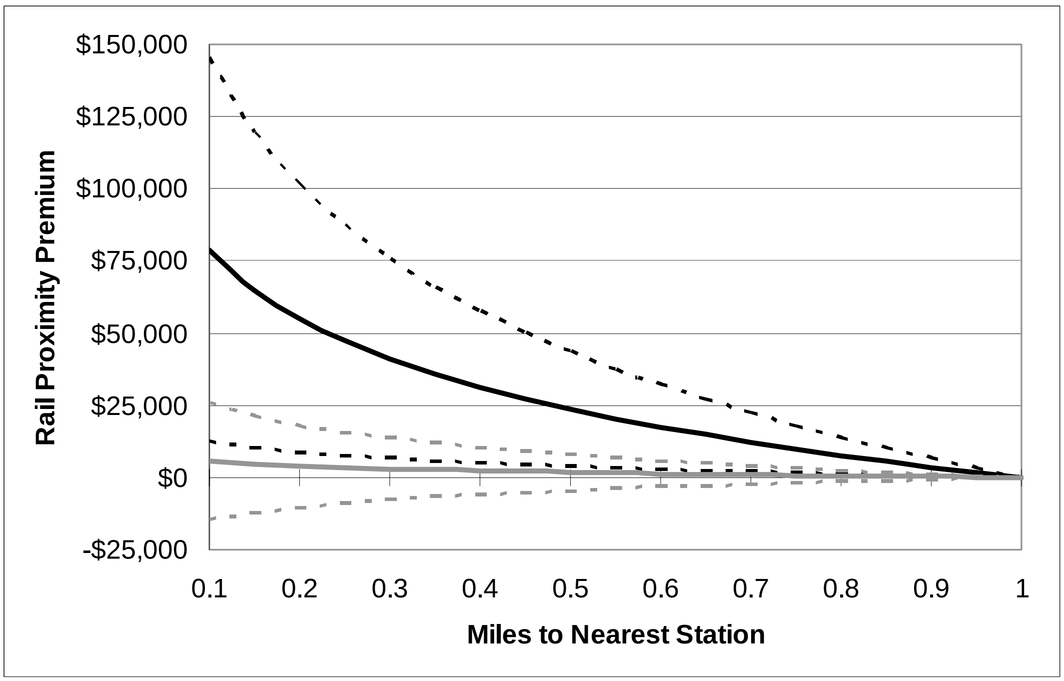


Figure 5.1 again provides strong evidence that permissive zoning significantly enhances the positive effect that rail proximity has on single family homes.

The Effect of Zoning Conditional upon Rail Proximity

Both zoning variables are larger and more significant (albeit only at the 0.10 level) in Model 5.B than they are in Model 5.A. These variables become constitutive

[96] The confidence intervals are based on standard errors calculated in the manner appropriate for interaction terms, as described in Chapter 3, section 3.4.

terms in Model 5.B and, therefore, the model parameters must be interpreted as the "true" coefficients only when **ln(rail_dis)** is equal to 0. Since the model uses a logarithmically transformed distance variable, this means that constitutive zoning coefficients only apply when a property is one mile from a station. For properties closer to the station, the zoning coefficients approach zero and/or become less significant. Tables 5.4 and 5.5 show the coefficients for the two zoning variables, respectively, at different distances from a station.

Table 5.4. Allowable Units per Acre (units_z1) Coefficients from Model 5.B, Conditional upon Rail Station Distance

Miles to Station	B	S.E.	T	SIG
0.1	-1,262.91	1,497.75	-0.84	0.401
0.25	-1,645.81	1,232.65	-1.34	0.180
0.5	-1,935.46	1,205.11	-1.61	0.107
0.75	-2,104.90	1,266.82	-1.66	0.097
1	-2,225.11	1,341.25	-1.66	0.097

Table 5.5. Allowable Units on Parcel (units_z2) Coefficients from Model 5.B, Conditional upon Rail Station Distance

Miles to Station	B	S.E.	T	SIG
0.1	4,170.32	7,824.92	0.53	0.596
0.25	-924.05	5,753.41	-0.16	0.873
0.5	-4,777.79	5,022.17	-0.95	0.342
0.75	-7,032.09	5,095.38	-1.38	0.168
1	-8,631.54	5,374.31	-1.61	0.107

Figure 5.2 below shows the estimated effect of the number of allowable units on a single family unit when the unit is close (500 ft) or relatively far (1 mile) from a rail station (again assuming a lot size of 0.17 acres).

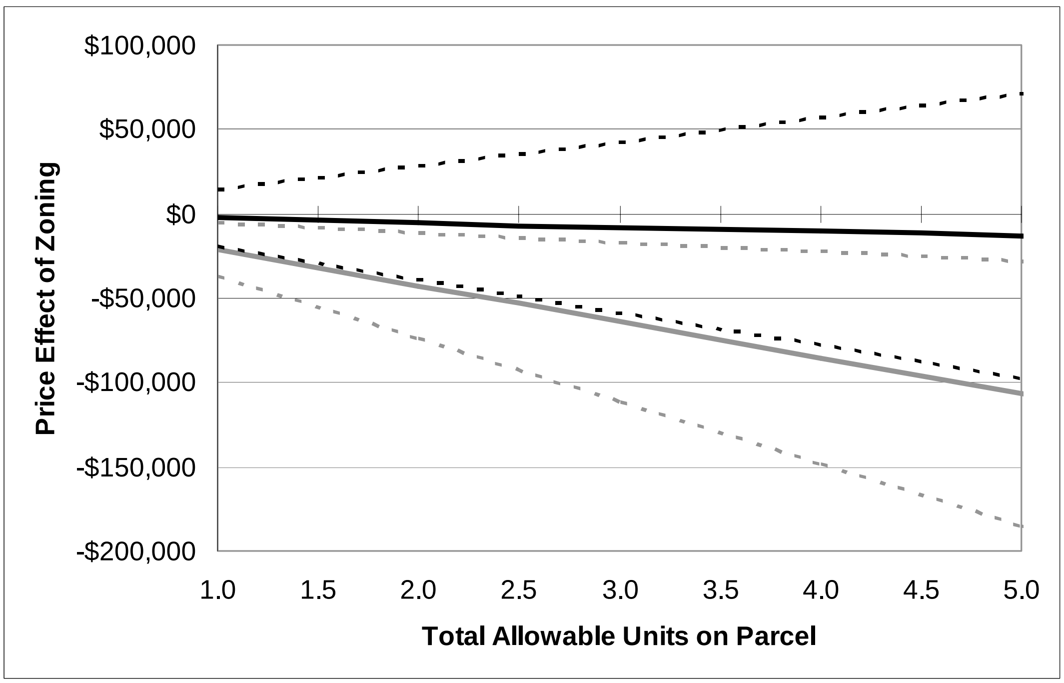
Figure 5.2. Price Effect of Zoning as Conditioned by Rail Station Distance

Black = 500 feet from station

Grey = 1 mile from station

Solid Line = Model Estimate

Dashed Line = 95% Confidence Interval



As Table 5.3, Table 5.4, and Figure 5.2 demonstrate, more permissive zoning has a mildly significant negative effect on home values when not near a rail station. In these areas, it seems the threat of nuisances (real or perceived) caused by permissive zoning outweighs redevelopment potential. For properties very close to a station, permissive zoning has a small and statistically insignificant effect on home values. In the station areas, the negative aspects of zoning seem to be muted or offset by potential for development at higher densities.

5.7 Interpretation of Findings

The findings from these models indicate that a single family home does not really gain much from rail proximity unless it is located in an area where the zoning ordinance permits higher density housing. Those on the market for a single family home in a typical single-use subdivision may not value rail proximity. For this market segment, the traffic, noise, and perceived increase in crime may offset the accessibility benefits (Nelson 1992). However, if there is sufficient demand for station area locations among other market segments who value TOD, developers would have an incentive to buy single family properties near stations and redevelop the parcel to highest possible density, although the cost of demolition surely reduces the incentive to redevelop. The returns a developer would receive from four or five additional units would likely lead them to bid more for a property than someone on the market for a single family home, increasing the overall market value for such properties.

The results presented above fall well short of definitive evidence that rail proximity would, if permitted, lead to the redevelopment of single family homes at higher densities. However, the illustrated pattern of home values seems congruent with such a hypothesis. Future research might use building permit data to more directly test whether station proximity does create a higher likelihood for redevelopment. Case studies might also help elucidate how station proximity and zoning have combined to change the character of station areas.

Chapter 6. Built Environment and Rail Transit Capitalization

This chapter will test how various elements of the built environment interact with station proximity to affect the sales price of condominiums. As mentioned in the previous chapter, such interactions were also tested for single family homes and not found significant. This likely stems from single family homes having limited diversity in urban form and simply because the overall station area premium is more limited for single family homes, and thus, limits the significance of interactions with rail distance. With condominiums, rail distance did significantly interact with several built environment and service quality variables and the following sections will describe these findings.

6.1. Theoretical Interaction between Rail Proximity and the Built Environment

The built environment of a neighborhood theoretically interacts with station proximity on several levels. Before exploring this in detail, a working definition of a "pedestrian-oriented" environment will be established. Following along the lines of Cervero and Kockleman (1997), three main elements define pedestrian orientation:

1) Design - The surrounding environment is physically designed in a manner that makes pedestrian movement easy, pleasant, and safe.
2) Density - There are a large number of travel destinations within walking distance.
3) Diversity - There is a good variety of travel destinations within walking distance.

The first way that pedestrian orientation theoretically enhances station area premiums is by creating good pedestrian connections to stations. Many transit users are also pedestrians because transit trips usually involve a non-motorized form of access or egress. Therefore, a household that valued station proximity would likely also value a location with a pleasant, flat, and safe pedestrian link to the station (Cervero 2001). By making it easy and enjoyable to access a station, a pedestrian-oriented neighborhood should enhance the rail transit capitalization benefits.

The idea of “market synergy” represents the second way that urban form interacts with station proximity. Chapter 2 (section 2.2) presented a list of population segments that likely make up the demand for station area property. These segments probably bare strong similarities to the population segments which make up the demand for a pedestrian-oriented neighborhood. This overlapping demand creates a situation where a household that values a pedestrian-oriented urban environment is more likely to value station proximity than a household that prefers the more typical auto-oriented form. Therefore, properties within pedestrian-oriented station areas will theoretically sell at greater premiums than more auto-oriented station areas.

This market synergy could occur completely by coincidence but, more likely, results from a complementary nature of two characteristics. In this case, rail transit proximity and walkable neighborhoods are complementary aspects of the “smart growth” or sustainable development movements that push for less use of the private automobile. In fact, there exists a large body of literature that analyzes, espouses, and criticizes transit-oriented development (TOD), which basically consists of station areas developed in a pedestrian-oriented manner (Cervero and Bernick, 1997, Rubin et al., 1999).

Rail access and pedestrian-oriented urban form prove especially complementary because they provide an alternative to the automobile for different types of trips. A pedestrian-oriented neighborhood should provide the ability to make trips for shopping, services, dining, and recreation by non-motorized means. Meanwhile, the nearby rail station might serve commute trips, as well as occasional discretionary trips to regional centers. Therefore, the combination of good rail *and* pedestrian access might allow a household to do without the expense of an automobile (or a second or third automobile for larger households) in a way that neither attribute could do separately.

The fixed monthly costs (payment and insurance) for a low end used automobile would run around $300. Put towards a mortgage payment, an additional $300 would allow the purchase of a property worth an additional $50,000 (the amount might be even greater when considering auto operating costs). Assuming a substantial number of households would actually be willing[97] and able[98] to make this tradeoff, a good portion of this $50,000 will get capitalized into locations that can fully facilitate auto independence. This could amount to a significant TOD premium.

Before describing the hypothesis for the analysis in this chapter, a simple typology of neighborhoods based on transit proximity and the built environment will be established. This typology will prove useful in defining the hypothesis and in generalizing the research findings. Figure 1 shows this typology in a two dimensional graph.

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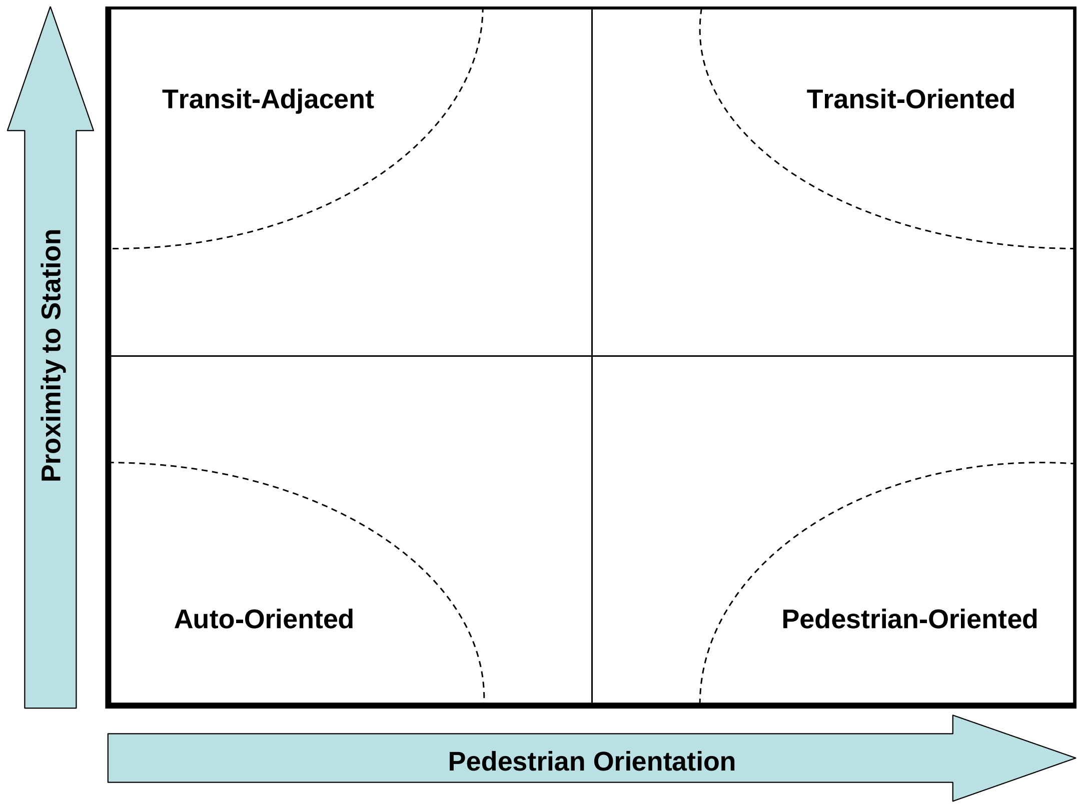
[97] The extremely high auto-ownership rates in the US indicate that very few households that could otherwise afford an automobile would be willing to make this trade-off.
[98] Many households may not qualify for an additional $50,000 on a mortgage.

Figure 6.1. Neighborhood Typology by Station Proximity and Pedestrian-Orientation



Because both variables that make up this typology are continuous, the category definitions will necessarily become fuzzy in the center. Neighborhoods within a five minute walk of a station would clearly fall in the top quadrants. Determining how far beyond this distance would cross into the lower quadrants requires some subjective judgment. Determining which neighborhoods would fall in the right hand (pedestrian-oriented) quadrants is even more complicated because of the various elements that make up pedestrian orientation. For example, a neighborhood might have density and diversity but poor pedestrian design (many suburban commercial centers fit this description). Despite the imprecision of these categories, they still serve well as a conceptual guide. The areas in the four corners of the chart (represented as half circles) symbolize the extreme ends of the spectrum where the neighborhoods would clearly fit within one of the four categories.

As has probably been made clear in previous sections, the hypothesis being tested in this chapter goes as follows:

Proximity to transit yields greater capitalization benefits when combined with pedestrian-oriented urban form.

This hypothesis can be restated using the previously established neighborhood typology. Auto-oriented neighborhoods served as the control group for transit-adjacent neighborhoods, while pedestrian-oriented neighborhoods served as the control for transit-oriented neighborhoods. The station area premium is the difference in property values between the two neighborhood types that are close to a station (the upper quadrants) and their respective control groups (the corresponding lower quadrants). Using these definitions, the hypothesis can now be stated this way:

(transit-oriented – pedestrian-oriented) > (transit-adjacent – auto-oriented)

6.2 Transit Service Quality and Capitalization

A secondary hypothesis will also be tested. Beyond urban form, the transit service quality at a particular station should affect the strength of the capitalization benefits associated with proximity to that station. Faster speeds, more frequent services, and proximity to desirable destinations will increase the accessibility benefits and, therefore, should increase premiums. It is therefore hypothesized that:

Properties located near stations that provide better service quality will receive greater capitalization benefits.

6.3 Interaction Model Findings

Table 6.1 presents the results of a condominium price model with 10 rail distance interactions. These interaction coefficients are presented on the right hand side of the table.

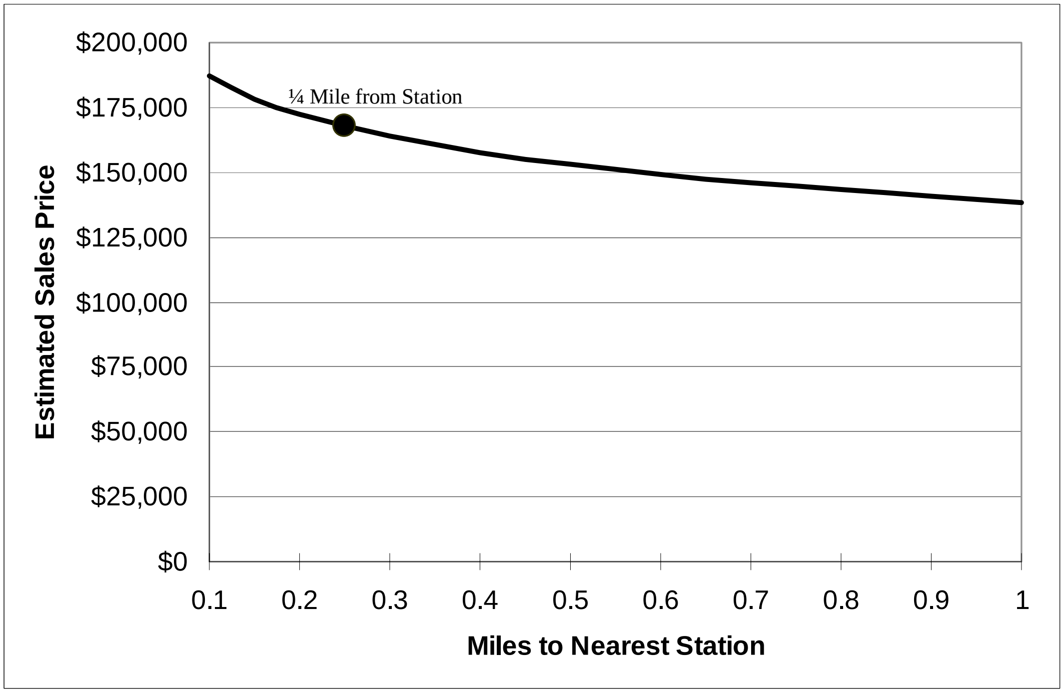
Table 6.1. Condominium Model with Rail Proximity Interactions

	OLS Estimation with Heteroskedastic-Robust Standard Errors Dependent Variable: Condominium Unit Sales Price					
				Rail Proximity Interaction Terms: ln(rail_dis)* variable		
	B	**Robust S.E.**	**SIG**	**B**	**Robust S.E.**	**SIG**
RAIL PROXIMITY						
ln(rail_dis)	-92,753.65	81,266.20	0.254			
PROPERTY CHARACTERISTICS						
str_sqft	198.58	15.52	0.000			
lot_acre	321,548.95	71,228.00	0.000			
str_age	-3,670.15	730.11	0.000			
str_age^2	58.74	18.02	0.001			
baths	-12,665.89	3,759.53	0.001			
beds	-14,498.36	4,073.55	0.000			
garages	3,114.06	1,810.17	0.085			
view	6,638.89	2,015.68	0.001			
view*coaster	26,067.24	10,405.80	0.012			
view*ocean	315,956.08	46,793.23	0.000			
NEIGHBORHOOD CHARACTERISICS						
hunits_g	-257.54	1,242.75	0.836	-1,210.88	1,242.48	0.330
fd_emp	1,839.48	8,410.65	0.827	-23,910.85	7,673.08	0.002
ae_emp	-56,041.63	150,396.82	0.709	-246,242.07	185,769.25	0.185
pr_emp	-14,108.53	11,001.85	0.200			
intrsctn	-53,288.19	27,524.02	0.053	-52,419.73	27,227.27	0.054
park_lot	-80,551.74	305,059.22	0.792	292,542.33	379,453.06	0.441
ocean	254,763.16	38,838.08	0.000			
bus_500	-10,558.46	4,530.29	0.020			
REGIONAL CHARACTERISITCS						
dt_auto	4,527.99	6,662.48	0.497	-6,241.32	2,671.90	0.020
dt_rail	-2,709.81	3,391.19	0.424	3,018.18	1,571.98	0.055
dt_ratio	-552,971.83	308,792.86	0.073	179,983.66	135,919.10	0.186
headway[99]				434.27	940.66	0.644
slope_r	630,124.21	202,387.07	0.002	596,451.82	198,630.28	0.003
constant	58,617.30	185,111.48	0.752			
N = 4,166 F = 225.86, P = .000 R^2 = .8416						

[99] There is not constitutive headway variable because it is fully captured in the neighborhood dummy variables.

With an R^2 of .84 the model has a strong overall fit. Most of the variables have significant and intuitive coefficients. The model does include some insignificant variables. As discussed in Chapter 3 (section 3.4), it is often appropriate to retain interaction terms and their corresponding constitutive terms even when not significant. Some of the constitutive variables also have seemingly counterintuitive signs or inappropriately large coefficients. This arises because the coefficient on a constitutive term is only considered the “true” coefficient when the companion constitutive variable(s) equals zero. Zero often falls out the companion variable’s realistic range, leading to coefficients that run counter to expectations. Proper interpretation requires looking at the interaction and constitutive terms in concert. For example, the coefficient for the rail distance variable is very large (in absolute terms) at -92,753 but not significant (.254). This coefficient and the corresponding standard error only apply when all 10 of the variables interacted with rail distance equal zero (this would never occur in reality). Assuming the 10 interaction variables equal their mean value provides a more realistic scenario. This brings the coefficient for rail distance to a more reasonable -21,042. This is fairly consistent with the rail distance coefficient from the previously presented condominium model without interactions (Model 4.B in Table 4.3), which estimates a coefficient of -16,196. Figure 6.2 graphically illustrates the price gradient associated with station proximity when mean values are assumed for all variables in the model.

Figure 6.2. Condominium Price Gradient for Rail Proximity (assumes mean values for all variables other than station distance)



The figure shows that the sales price of a condo increases by roughly $25,000 dollars when moving from 1 mile to ¼ miles (represented by the black dot) from a station. The percent premium will depend on the base value of the property, which depends highly on the size and quality of the unit. The scenario presented in Figure 6.1 assumes the mean values for a condominium unit in the model database. The base value under these assumptions is roughly $140,000, meaning the predicted premium for an "average"[100] condominium unit near a station is approximately 18 percent (25/140). This is beyond the range typically found in previous transit capitalization

[100] Assuming mean values for all neighborhood, property, and regional variables may not be realistic. Therefore, the 18 percent premium may not apply to a broad range of properties.

studies[101]. The next sections will illustrate how the station area premiums can rise even higher when combined with pedestrian friendly built environment and high quality transit service.

6.4 Analyzing Station Proximity Interactions

As previously described, interaction terms can be difficult to understand. To ease interpretation, Tables 6.2 and 6.3 analyze how the rail distance variable interacts with the six[102] built environment characteristics and 4 measures of transit service quality, respectively. For each of these 10 variables, the tables provide the predicted sales price for high (90th percentile) and low values (10th percentile) at close (1/4 mile) and far (1 mile) distances from a rail station while all other variables are held constant at their mean value. Rail proximity premiums are calculated for high and low values of each variable based on the difference in price between close and far properties. Before presenting these tables, it should be noted that allowing a variable to move to its extremes while holding all other variables constant at their mean value will be unrealistic in some cases. For example, it is highly unlikely that auto travel time to the CBD (**dt_auto**) will be at its mean value (26 minutes) when rail travel time to the CBD (**dt_rail**) is at its 10th percentile value (33 minutes), especially for a property that is not in the immediate vicinity of a station. Therefore, the presented price estimates are sometimes implausible (even negative in one case). Nonetheless, the tables provide

[101] Studies about single family properties dominate the literature. As has been demonstrated in previous chapters, single family properties many not benefit from rail proximity as much as condominiums and one would therefore expect the premium for condominiums to be at the high end of the spectrum.
[102] Slope between the property and the nearest station is included in this category even though this technically is not part of the "built" environment.

useful information in terms of understanding the magnitude and direction of each variable's interaction with rail proximity.

Table 6.2. Interaction of Built Environment Characteristics and Station Proximity

	Variable Value	Station Distance		Rail Proximity Premium	
		1/4 Mile	1 Mile	$	%
fd_emp	0.05	$153,451	$137,667	$15,784	11.5%
	1.25	$195,312	$139,868	$55,444	39.6%
ae_emp	0.00	$159,134	$140,070	$19,064	13.6%
	0.06	$177,122	$136,536	$40,586	29.7%
intrsctn	0.05	$165,161	$145,064	$20,097	13.9%
	0.37	$171,411	$127,878	$43,533	34.0%
hunits_g	2.82	$163,290	$139,188	$24,102	17.3%
	9.47	$172,731	$137,477	$35,254	25.6%
park_lot	0.00	$169,455	$138,721	$30,734	22.2%
	0.01	$163,004	$137,652	$25,352	18.4%
slope_r	0.00	$169,737	$131,505	$38,232	29.1%
	0.03	$163,714	$150,795	$12,919	8.6%

Most of the built environment variables have the expected interaction with rail proximity. Higher station proximity premiums are generally found when the variables tilt toward the pedestrian-oriented end of the spectrum, in some cases generating premiums in excess of 30 percent. Some more specific inferences from this table include:

- The largest premiums are found when there is a strong presence of food and arts/entertainment employment (**fd_emp**, **ae_emp**), which serve as good proxies for an urban milieu in a neighborhood.
- More street intersections per acre (**intrsctn**), which captures the permeability and density of the pedestrian network, notably enhances the rail capitalization benefits.

- Having a flat path between the property and station (**slope_r**) appreciably improves the value of rail proximity. In many cases the rail stations in San Diego are located at the base of a hill[103]. This analysis provides evidence that this, in effect, limits the area that receives capitalization benefits.
- Having a park-and-ride (**park_lot**) lot near the station does slightly diminish capitalization benefits near the station. Since park-and-ride lots can confer benefits to a much wider geographic area than immediately around the station, the lost capitalization benefits may be a small part of the overall picture. However, the potential for park-and-rides to weaken land use impacts should come under consideration when designing a rail system.
- Housing density (**hunits_g**) can positively influence capitalization benefits, though not to the degree of non-residential uses. Residential density likely enhances capitalization benefits because it provides the critical mass needed to engender a lively and safe pedestrian environment.

[103] The stations immediately north of the CBD on the Trolley blue line come to mind.

Table 6.3. Interaction of Transit Service Quality and Station Proximity

	Variable Value	Station Distance		Rail Proximity Premium	
		1/4 Mile	1 Mile	$	%
dt_rail (dt_auto is constant)	34	$77,348	$31,877	$45,471	142.6%
	83	$100,724	$149,102	-$48,378	-32.4%
dt_rail (dt_ratio is constant)	34	$183,574	$151,327	$32,247	21.3%
	83	$147,114	$121,881	$25,233	20.7%
dt_auto (dt_rail is constant)	13	$193,937	$209,442	-$15,506	-7.4%
	50	$116,846	-$12,158	$129,005	n/a
dt_auto (dt_ratio is constant)	13	$188,057	$154,948	$33,110	21.4%
	50	$129,798	$107,896	$21,902	20.3%
dt_ratio (dt_auto is constant)	0.35	$135,596	$152,758	-$17,162	-11.2%
	0.67	$121,942	$72,840	$49,102	67.4%
dt_ratio (dt_rail is constant)	0.35	$182,285	$175,948	$6,337	3.6%
	0.67	$147,901	$77,110	$70,791	91.8%
headway	8.6	$173,457	$138,410	$35,047	25.3%
	30	$160,574	$138,410	$22,164	16.0%

The reader will notice that Table 6.3 contains two entries for **dt_rail**, **dt_auto**, and **dt_ratio**. This is because **dt_ratio** = **dt_auto**/**dt_rail**, making it impossible to hold more than one of these variables constant. Therefore, the price estimates are repeated holding one or the other of these variables constant. Generally speaking the table confirms the hypothesis that higher service quality (i.e., faster rail travel times to downtown[104], slower auto travel times to downtown[105], and shorter headways) can enhance rail capitalization benefits. The magnitude of these interactions seems greater than the built environment interactions, although these interactions seem more subject to the problem of unrealistic scenarios[106] previously discussed. Some other key inferences include:

[104] More general accessibility measures were also tested but CBD travel time interacted much more strongly and rendered the accessibility measures insignificant.
[105] After controlling for rail travel times, slower auto travel times mean that rail is more competitive with the auto.
[106] The largest premium percentages result from unrealistic base values below $100,000.

- When the ratio between auto and rail travel time is held constant, the percent premium remains stable whether close or far from the CBD. The ability of transit to provide competitive travel times seems to be more valuable than CBD proximity. This generally favors the commuter rail service which has widely spaced stations and faster speeds. In San Diego, the Coaster also has the advantage of serving the congested I-5 corridor.
- Service frequency (**headway**) enhances premiums but not to the same degree as travel time. The Coaster operates on 40 minute peak headways as compared to 15 or 7.5 minute headway for the Trolley. This offsets some of the advantage that the Coaster gains from providing more competitive travel times.

6.6 Pedestrian-Oriented vs. Auto-Oriented Neighborhoods

Based on the model results, it is apparent that individual elements of pedestrian-orientation amplify capitalization benefits. The following analysis will test the premiums values when the various element of pedestrian orientation are combined together. This required making some arbitrary assumptions about what determines a pedestrian-oriented and auto-oriented neighborhood. As done previously, the 10^{th} and 90^{th} percentile values variables were used to define the neighborhood types. Table 6.4 present the neighborhood type assumptions.

Table 6.4. Neighborhood Type Assumptions

	Pedestrian-Oriented	Auto-Oriented
food jobs/acre	1.25	0.05
arts/entertainment jobs/acre	0.06	0.00
street intersections/acre	0.37	0.05
gross housing units/acre	9.47	2.82
proportion of land in park-and-ride	0.000	0.013

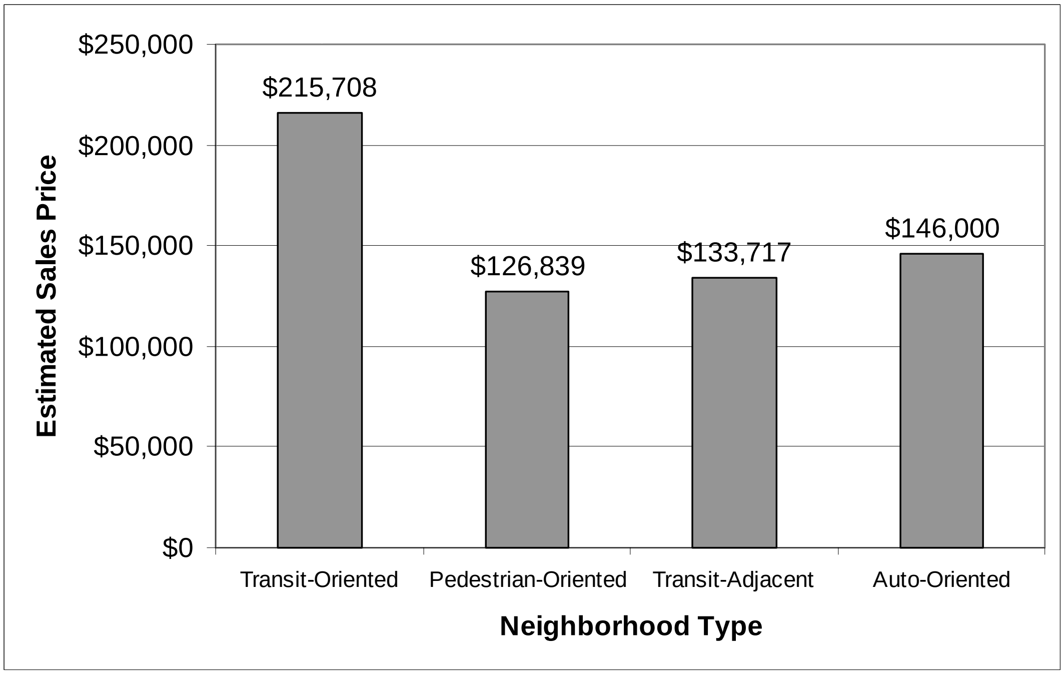
The values presented in Table 6.4 were then applied to the price model to predict sales prices for auto-oriented and pedestrian-oriented neighborhoods that are both near (1/4 mile) and far (1 mile) from a rail station (this is equivalent to the four category neighborhood typology presented earlier in Figure 6.1). Variables not listed in the table were set at their mean values for both neighborhood types. Table 6.5 presents the estimated prices and rail proximity premiums by neighborhood type.

Table 6.5. Rail Proximity Premium by Neighborhood Type

Neighborhood Type	Station Distance		Rail Proximity Premium	
	1/4 Mile	1 Mile	$	%
Pedestrian-Oriented	$215,708	$126,839	$88,869	70.1%
Auto-Oriented	$133,717	$146,000	-$12,283	-8.4%

The predicted values plainly confirm the hypothesis that pedestrian-oriented neighborhoods receive greater benefits from rail proximity. A pedestrian oriented neighborhood has an extremely large rail proximity premium of $89,000 and 70%. Properties in auto-oriented neighborhood are actually slightly discounted near rail. Using the nomenclature of the neighborhood typology defined earlier, Figure 6.3 illustrates the overwhelming differential between transit-oriented neighborhoods and the three other neighborhood types.

Figure 6.3. Estimated Condominium Price by Neighborhood Type



Pedestrian-oriented neighborhoods ostensibly have a market synergy with station proximity that does not exist in an auto-oriented neighborhood. It is unclear why pedestrian-oriented neighborhoods have values lower than other neighborhood types. Recent work has shown that walkable and mixed use environments have value independent of rail (Song & Knapp 2003, Eppli & Tu 1999). It may well be that the pedestrian-oriented neighborhoods near rail stations in San Diego are qualitatively better than those not near rail. This could be because the presence of rail has shaped a better pedestrian environment or because some rail stations were placed in the best pedestrian environments. Further research that examines the pedestrian environment at locations near and far from stations over time would provide some enlightenment on this issue.

Chapter 7. Conclusion

7.1 Summary of Findings

The major findings from the quantitative analysis presented above are:

(1) Condominiums receive larger capitalization benefits from station proximity than do single family homes. All other things equal, both property types have a statistically significant decrease in value moving away from a station but condominiums decrease at a much faster rate. Comparing similar properties ¼ mile and 1 mile from a station, the condominium model predicts an additional value of $25,000 for the closer property. The single family model predicts an additional value of only $10,000 for the closer property.

(2) Single family properties that could potentially be redeveloped at higher densities (i.e., properties zoned for higher unit densities combined with a large lot size) receive greater capitalization benefits from rail proximity. Again comparing properties ¼ and 1 mile from a station, for a property with large redevelopment potential[107], the model predicts that the closer property will have an additional value of $50,000. For a property with no redevelopment potential[108], the model predicts no additional value for the closer property.

(3) Condominiums in walkable neighborhoods receive greater capitalization benefits from rail proximity than those in more auto-oriented neighborhoods. Again comparing

[107] "Large redevelopment potential" assumes a .17 acre lot (the mean lot size in among the single family properties in the database) and a zoning code that allows 30 units per acre. This translates to having the potential to redevelop this single family property to a 5 unit property.

[108] "No redevelopment potential" also assumes a .17 acre lot but now the zoning code that allows only 6 units per acre. This translates to having only one unit allowed on the property and, thus, no redevelopment potential.

properties ¼ and 1 mile from a station, the model predicts that, for a property in a walkable neighborhood (as defined previously in table 6.5), the closer property will sell at a premium of more than $89,000. For a property in an auto-oriented neighborhood, the model predicts that the closer property will actually be discounted by $12,000.

7.2 Conclusions

External Validity

Before making any general conclusions about the research findings, a caveat about external validity must be made. This study focuses on a single region and, thus, the result will apply most directly to San Diego. The conditional nature of transit capitalization that has been empirically illustrated in this work seems intuitive enough that it should generalize to other regions. However, this is an educated guess on the part of the author. Obviously, applying a similar analysis to data from other regions would provide the only true verification of how well the results of this research generalize to other places.

The Market for TOD

This research adds some nuance to previous work in transit capitalization. To the degree that the previously presented models are well-specified and an accurate reflection of reality, this research illustrates that premiums associated with rail proximity can be well above the "modest" level generally found in the literature when combined with complementary elements. More specifically, an urban or TOD-style built environment enhances rail capitalization benefits. This "TOD-style" built environment might come in the form of higher density housing (i.e., condos instead of single family units) or a neighborhood that provides a diversity of land uses and a permeable street pattern that favors pedestrian activity. Potential for this kind of development (i.e., zoning that permits redevelopment at higher densities) also enhances capitalization benefits.

The policy relevance of these findings lies in the fact that they provide evidence of TOD's market viability. Many regions, San Diego included, have accepted TOD as a key component in their efforts to remedy congestion, pollution, and sprawl (Wilbur Smith Associates 2006). The 2004 "Regional Comprehensive Plan" produced by San Diego's MPO (SANDAG) identifies several "smart growth" centers, many around rail stations, where compact, pedestrian-friendly, and mixed-use development will be emphasized. However, despite the dedication to TOD as a policy instrument, a market must exist for this kind of development in order for the policy to have any effect.

This research shows that in San Diego, TOD can generate premiums of more than $50,000 per housing[109] unit. Conversely, the model found much more limited premiums (if at all) for transit-adjacent housing (i.e., housing located close to rail but in a more typical auto-orientated neighborhood). Given these findings, it seems that a substantial market for TOD around stations exists. The large premiums for TOD housing units should, in an unfettered market, lead to an increased supply of such

[109] Since this research has focused on housing, it provides a good indicator about the market for housing in TODs but the market for commercial property requires further research.

units[110]. In reality, creating the mixed use environment inherent in TOD has many obstacles (Cervero et al. 2002). However, the market pressure to increase TOD supply should ease the effort required by the public sector to channel development toward the desired development goals.

Making Station Areas More Desirable

Many station areas (in San Diego and elsewhere) lack the transit-oriented elements that this research has shown to increase property sales prices. In many cases, these areas have already been "built out" and cannot easily be changed. Carefully designed[111] zoning regulations that allow higher unit densities and supportive commercial/retail uses would provide long term prospect for change. When and if the market reaches a tipping point, redevelopment towards a more transit-oriented built environment will occur. Many communities have chosen the opposite approach and downzoned in station areas (Cervero & Landis 1997). While this may preserve a community's character (usually single use residential development), this research provides evidence that it will likely limit the capitalization benefits generated by station proximity.

Pedestrian improvements present another way that station areas with an auto-oriented environment can be made more pedestrian friendly, thus increasing the rail proximity premiums. The variable used to measure pedestrian design in the above

[110] To estimate how much more TOD housing could be supported would require some kind of housing equilibrium model that goes far beyond the complexity of the models that have been estimated for this analysis.

[111] A "carefully designed" zoning ordinance would take into account the current mix of uses both at the station in question and at other stations on the rail system to maintain the right balance between commercial and residential uses.

presented models is the number of intersections per land acre, which cannot easily be changed on the ground. However, this variable really stands as a proxy for the permeability of the walking network. Various interventions can have a similar effect without a wholesale realignment of the network (Litman et al. 2006). This might include widening sidewalks (or adding sidewalks if they don't exist), more frequent cross-walks, road medians, bus bulbs, speed bumps, traffic calming road blocks, bike lanes, and pedestrian pathways that connect circuitous roads.

Remaking a fully developed auto-oriented neighborhood into something more compact and pedestrian-friendly is unlikely and would require a slow and difficult redevelopment period. Therefore, the selection of station locations is a critical point in determining whether and how fast TOD will occur. This means choosing locations where a complementary built environment already exists or where there is plentiful developable land to create such an environment. When dealing with developable land, NIMBY resistance or a stagnant local land market may prevent TOD from occurring. Therefore, a strategy of building TOD from scratch requires an assessment of whether the desired development can truly occur. A common criterion for choosing a rail alignment has been a cheap right-of-way. This has translated to using a previously abandoned railroad corridor, which is often industrial and has limited development potential beyond a park-and-ride facility (Kahn 2007). San Diego has several stations[112] that, due to their location in isolated industrial zones, have bleak prospects for future development. In the overall analysis, choosing the lowest cost right-of-way may be a prudent mobility strategy for a given region but deciding on such a strategy

[112] The 8th station in National City and Weld Boulevard station in El Cajon are examples of isolated park-and-ride stations in industrial settings.

must account for lost capitalization benefits and other public benefits associated with TOD. The lost capitalization benefits will not necessarily be a monetary concern. Unless a value capture system is in place, most of the capitalization benefits will accrue to private property owners, although the local government may recoup a small portion of these benefits though increased property taxes. The capitalization benefits provide a market indicator of the public desirability of the station areas which, given the potential public benefits provide by TOD, should go into the accounting of a public investment such as a new rail system

7.3 Further Research

Due to the limited scope of this analysis, it has left many important questions unanswered. The following sections will outline some of these issues and suggest avenues for future research.

Other Regions

As previously discussed, the focus on a single region limits the external validity of the study findings. Examining the conditional nature of transit capitalization is the unique contribution of this research. Further research should explore whether the conditional relationships that have been empirically demonstrated in San Diego hold up in other regions.

Other Property Types

This analysis has focused on single unit housing purchases. Examining the conditional nature of capitalization benefits for rental housing and commercial properties would provide a fuller picture. This has a particular importance in the case of commercial properties since the presence of such uses has been shown to enhance capitalization benefits of condominiums. It would be valuable to know if this relationship is reciprocal. In other words, does the presence of high density housing enhance the rail capitalization benefits that accrue to commercial properties?

Causality

As was outlined in the literature review, a cross-sectional analysis, such as what has been used in this research, does not determine causality. It would be informative to try and repeat the analysis using panel regression or a “difference in differences” approach. This would require not only a longitudinal record of property sales but also a corresponding longitudinal record of land use and zoning changes. While this may not be readily available for most regions at the current time, the evolution of GIS and digital property records may make this kind of data more available in the future.

Comparing Stated and Revealed Preferences

The research looks at revealed preference for certain kinds of station areas through property sales prices. It would be interesting to survey households and measure how the stated preferences for certain station areas (i.e., how much did the station have to do with a particular location choice) match up with the patterns of revealed preferences illustrated in this work.

Redevelopment Potential

As previously discussed, many station areas will require significant redevelopment in order to obtain some semblance of transit-oriented form. Chapter 5 presents some evidence that the potential for redevelopment has value. Further research is needed that shows whether station proximity makes redevelopment at higher densities more likely

Built Environment Measures

Following along the lines of Song & Knaap (2004), many variables that seek to capture the nature of the built environment have been created and tested in the regression models (many of which were not used in the final models). However these often fall short of capturing the details that can truly enhance the walkability of a neighborhood (e.g., sidewalks, street trees, interesting storefronts, and the type and quality of commercial activity). Such detailed variables have rarely been systematically gathered across a large area in a way that would facilitate quantitative analysis. As more fine-grained data is collected on a wider scale and made available it should be integrated into future research.

Case Studies

Data restrictions often limit the inference of large scale quantitative analysis. Case studies provide a way to fill in the gaps. In the case of the present research, much could be gained by picking high performing and low performing[113] station areas and conducting an in depth analysis which would include:

- A visual survey of the area
- A detailed history of zoning, land use, and land values both before and after the introduction of rail
- Interviews with local residents, business owners, and planners
- A detailed analysis of travel behavior in the area.

This case study approach would likely provide important detailed information that the research presented in this dissertation has missed. This information could, in turn, inform a better quantitative model specification.

Equity Concerns

This research has shown the capitalization process will increase the price of housing near stations with TOD. This will likely make such areas unaffordable for the poor who might benefit most from them. Further research is required that examines ways to mitigate this impact. Location efficient mortgages[114] (Krizek 2003, Blackman & Krupnick 2001), requirements for affordable housing, and simply increasing the supply provide examples of some strategies that merit further study.

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[113] High performing and low performing areas could be picked by looking at the predicted capitalization benefits or by looking at the residuals from the quantitative analysis.

[114] Location efficient mortgages allow a household to qualify for a greater loan if they purchase a home in an area designated as providing travel cost savings.

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Appendix A: Descriptive Statistics and Coefficients for Neighborhood and Municipal Dummy Variables

Table A3.2. Neighborhood and Municipal Summary Statistics

	Single Family N = 4,970		Condominium N = 4,166		Combined N = 9,136	
	Frequency	Proportion	Frequency	Proportion	Frequency	Proportion
COASTER STATION NEIGHBORHOODS						
Oceanside	235	0.047	228	0.055	463	0.051
Carlsbad Village	85	0.017	111	0.027	196	0.021
Carlsbad Poinsettia	8	0.002	38	0.009	46	0.005
Encinitas	171	0.034	209	0.050	380	0.042
Solana Beach	153	0.031	298	0.072	451	0.049
NORTH BLUE LINE NEIGHBORHOODS						
Mission San Diego			639	0.153	639	0.070
Qualcomm	2	0.000			2	0.000
Fenton			117	0.028	117	0.013
Rio Vista	4	0.001	12	0.003	16	0.002
Hazard Center			334	0.080	334	0.037
Fashion Valley	1	0.000	245	0.059	246	0.027
Morena	66	0.013	532	0.128	598	0.065
Old Town	48	0.010	96	0.023	144	0.016
Washington	145	0.029	66	0.016	211	0.023
Middletown	35	0.007	32	0.008	67	0.007
SOUTH BLUE LINE NEIGHBORHOODS						
Barrio Logan	7	0.001			7	0.001
Harborside	14	0.003			14	0.002
Pacific Fleet	14	0.003	1	0.000	15	0.002
8th Street	53	0.011	7	0.002	60	0.007
24th Street	46	0.009	5	0.001	51	0.006
Bayfront	96	0.019	66	0.016	162	0.018
H Street	100	0.020	74	0.018	174	0.019
Palomar	66	0.013	35	0.008	101	0.011
Palm	107	0.022	31	0.007	138	0.015
Iris	172	0.035	300	0.072	472	0.052
Beyer	97	0.020	93	0.022	190	0.021
San Ysidro	2	0.000			2	0.000

Table A3.2. Neighborhood and Municipal Summary Statistics (continued)

	Single Family N = 4,970		Condominium N = 4,166		Combined N = 9,136	
	Frequency	Proportion	Frequency	Proportion	Frequency	Proportion
ORGANGE LINE NEIGHBORHOODS						
25th & Commercial	80	0.016			80	0.009
32nd & Commercial	196	0.039	11	0.003	207	0.023
47th Street	148	0.030	19	0.005	167	0.018
Euclid	222	0.045	8	0.002	230	0.025
Encanto	375	0.075	18	0.004	393	0.043
Massachusetts	565	0.114	30	0.007	595	0.065
Lemon Grove	278	0.056	37	0.009	315	0.034
Spring	71	0.014			71	0.008
La Mesa	378	0.076	113	0.027	491	0.054
Grossmont	207	0.042			207	0.023
Amaya	216	0.043	79	0.019	295	0.032
El Cajon	235	0.047	66	0.016	301	0.033
Arnele	160	0.032	15	0.004	175	0.019
Gillespie Field	26	0.005	17	0.004	43	0.005
Santee	86	0.017	184	0.044	270	0.030
MUNCIPALITIES						
Oceanside	244	0.049	246	0.059	490	0.054
Carlsbad	84	0.017	131	0.031	215	0.024
Encinitas	171	0.034	209	0.050	380	0.042
Solana beach	153	0.031	298	0.072	451	0.049
San Diego	1877	0.378	2554	0.613	4431	0.485
National City	99	0.020	12	0.003	111	0.012
Chula Vista	262	0.053	175	0.042	437	0.048
Lemon Grove	652	0.131	50	0.012	702	0.077
La Mesa	850	0.171	209	0.050	1059	0.116
El Cajon	424	0.085	98	0.024	522	0.057
Santee	107	0.022	184	0.044	291	0.032
unincorporated	47	0.009			47	0.005

Table A4.3. Neighborhood and Municipal Dummy Coefficients from the Condominium and Single Family Price Model Comparison

	OLS Estimation with Heteroskedastic-Robust Standard Errors					
	Model 4.A, Dependent Variable: Single Family Unit Sales Price			Model 4.B, Dependent Variable: Condominium Unit Sales Price		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
COASTER STATION NEIGHBORHOODS						
Oceanside	121,411.34	10,554.16	0.000	271,570.88	37,170.64	0.000
Carlsbad Village	151,732.11	25,131.58	0.000	191,872.17	32,205.13	0.000
Carlsbad Poinsettia	240,754.17	46,551.34	0.000	Suppressed Category		
Encinitas	225,380.23	16,087.86	0.000	314,077.84	38,416.11	0.000
Solana Beach	387,559.35	16,345.73	0.000	367,856.81	31,909.55	0.000
NORTH BLUE LINE NEIGHBORHOODS						
Mission San Diego				305,886.33	43,274.37	0.000
Qualcomm	117,948.87	27,766.66	0.000			
Fenton				321,398.28	41,981.88	0.000
Rio Vista	144,321.20	16,426.03	0.000	265,803.07	48,207.85	0.000
Hazard Center				280,470.98	38,363.22	0.000
Fashion Valley				288,677.98	38,416.71	0.000
Morena	181,364.93	14,307.70	0.000	319,638.97	40,709.22	0.000
Old Town	290,165.77	21,375.03	0.000	294,325.76	43,494.40	0.000
Washington	219,816.20	9,192.19	0.000	293,727.77	46,656.10	0.000
Middletown	189,427.99	13,678.34	0.000	325,863.27	43,725.29	0.000
SOUTH BLUE LINE NEIGHBORHOODS						
Barrio Logan	47,811.21	14,658.39	0.001			
Harborside	46,199.02	14,915.34	0.002			
Pacific Fleet	54,275.21	13,660.07	0.000			
8th Street	29,577.62	6,926.13	0.000	266,835.12	43,412.21	0.000
24th Street	60,212.62	10,163.50	0.000	214,427.88	41,896.23	0.000
Bayfront	108,720.28	11,848.82	0.000	262,738.41	42,472.51	0.000
H Street	95,253.22	11,985.82	0.000	244,919.97	40,665.06	0.000
Palomar	87,146.88	12,305.03	0.000	264,575.69	41,808.62	0.000
Palm	64,233.77	11,825.99	0.000	226,778.75	40,915.71	0.000
Iris	74,815.25	12,035.94	0.000	260,208.22	42,800.93	0.000
Beyer	67,971.35	11,659.92	0.000	260,295.50	42,804.78	0.000
San Ysidro	65,713.73	19,606.97	0.001			

Table A4.3. Neighborhood and Municipal Dummy Coefficients from the Condominium and Single Family Price Model Comparison (continued)

	Model 4.A, Dependent Variable: Single Family Unit Sales Price			Model 4.B, Dependent Variable: Condominium Unit Sales Price		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
ORGANGE LINE NEIGHBORHOODS						
25th & Commercial	Suppressed Category					
32nd & Commercial	29,586.92	7,271.17	0.000	209,363.20	46,022.92	0.000
47th Street	60,087.98	11,285.40	0.000	187,229.97	41,148.37	0.000
Euclid	35,936.02	11,078.27	0.001	279,362.82	42,738.06	0.000
Encanto	36,298.66	11,323.43	0.001	192,499.28	38,655.88	0.000
Massachusetts	49,151.07	12,447.30	0.000	257,734.92	40,853.36	0.000
Lemon Grove	56,160.54	12,426.96	0.000	229,069.94	41,518.57	0.000
Spring	68,166.51	13,353.93	0.000			
La Mesa	61,941.10	10,571.60	0.000	245,120.15	47,242.90	0.000
Grossmont	78,649.72	13,877.23	0.000			
Amaya	63,999.84	13,586.42	0.000	227,931.18	42,842.50	0.000
El Cajon	32,478.13	13,379.48	0.015	235,235.61	37,848.29	0.000
Arnele	62,093.86	14,613.33	0.000	256,346.66	38,494.55	0.000
Gillespie Field	64,094.61	21,299.51	0.003	247,854.76	37,221.14	0.000
Santee	63,309.40	21,606.18	0.003	246,749.48	36,923.85	0.000
MUNCIPALITIES						
Carlsbad	20,913.95	21,590.17	0.333	138,309.54	23,167.22	0.000
Lemon Grove	10,789.79	2,412.67	0.000			
La Mesa	32,641.43	4,384.68	0.000	13,171.91	12,024.05	0.273
El Cajon	45,653.64	7,148.32	0.000			
Santee	31,669.10	17,493.38	0.070			
unincorporated	26,290.55	8,081.82	0.001			

Table A5.1. Neighborhood and Municipal Dummy Coefficients from the Single Family Models with Endogenous Zoning Variables

	2SLS Estimation with Heteroskedastic-Robust Standard Errors Dependent Variable: Single Family Unit Sales Price					
	Model 5.A Without Zoning/Rail Interactions			Model 5.B With Zoning/Rail Interactions		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
COASTER STATION NEIGHBORHOODS						
Oceanside	113,811.90	11,187.11	0.000	113,450.10	11,455.05	0.000
Carlsbad Village	131,856.40	24,592.27	0.000	130,820.20	26,469.63	0.000
Carlsbad Poinsettia	200,581.70	44,329.41	0.000	205,807.40	46,602.47	0.000
Encinitas	216,215.80	15,544.25	0.000	216,057.00	15,678.38	0.000
Solana Beach	375,146.00	16,042.05	0.000	372,915.30	16,239.78	0.000
NORTH BLUE LINE NEIGHBORHOODS						
Qualcomm	114,403.70	18,104.92	0.000	114,091.30	18,476.38	0.000
Rio Vista	106,174.50	19,033.35	0.000	100,735.50	20,870.84	0.000
Morena	181,327.30	14,487.44	0.000	182,272.90	14,903.32	0.000
Old Town	291,233.20	21,987.94	0.000	289,252.70	22,202.25	0.000
Washington	227,377.60	10,490.28	0.000	226,829.20	11,301.75	0.000
Middletown	181,619.10	14,940.73	0.000	181,378.50	15,714.70	0.000
SOUTH BLUE LINE NEIGHBORHOODS						
Barrio Logan	51,068.57	15,444.95	0.001	55,570.30	17,355.24	0.001
Harborside	44,709.86	15,180.51	0.003	46,146.99	15,607.44	0.003
Pacific Fleet	54,015.47	15,764.81	0.001	60,480.66	17,697.39	0.001
8th Street	9,346.62	11,288.39	0.408	4,647.36	11,788.35	0.693
24th Street	46,424.40	11,134.19	0.000	46,877.85	11,396.22	0.000
Bayfront	110,299.30	12,855.80	0.000	114,669.40	13,938.68	0.000
H Street	85,653.79	12,012.07	0.000	86,362.07	12,297.89	0.000
Palomar	79,361.82	12,428.68	0.000	77,486.88	12,733.76	0.000
Palm	60,319.62	11,722.29	0.000	61,289.60	11,920.41	0.000
Iris	69,521.14	12,048.00	0.000	71,362.35	12,336.55	0.000
Beyer	57,726.95	11,636.80	0.000	57,094.21	11,804.59	0.000

Table A5.1. Neighborhood and Municipal Dummy Coefficients from the Single Family Models with Endogenous Zoning Variables (continued)

	Model 5.A Without Zoning/Rail Interactions			Model 5.B With Zoning/Rail Interactions		
	B	**Robust S.E.**	**SIG**	**B**	**Robust S.E.**	**SIG**
ORGANGE LINE NEIGHBORHOODS						
25th & Commercial	Suppressed Category					
32nd & Commercial	29,853.57	7,991.99	0.000	30,205.86	8,276.99	0.000
47th Street	59,196.29	11,640.27	0.000	62,136.50	12,143.12	0.000
Euclid	35,548.75	11,200.71	0.002	37,937.96	11,664.82	0.001
Encanto	34,641.11	11,266.65	0.002	36,364.65	11,593.01	0.002
Massachusetts	51,217.83	12,439.51	0.000	54,428.28	12,932.17	0.000
Lemon Grove	57,809.38	12,593.56	0.000	59,150.05	12,902.81	0.000
Spring	68,037.20	13,453.66	0.000	69,867.01	13,849.34	0.000
La Mesa	63,445.19	11,594.34	0.000	65,508.94	11,995.77	0.000
Grossmont	80,313.63	13,901.01	0.000	82,914.35	14,300.84	0.000
Amaya	64,579.27	13,375.89	0.000	66,380.17	13,678.65	0.000
El Cajon	35,373.61	13,637.64	0.009	38,172.66	14,122.33	0.007
Arnele	58,336.95	14,438.98	0.000	60,424.06	14,741.62	0.000
Gillespie Field	70,588.16	20,180.10	0.000	73,873.60	20,574.21	0.000
Santee	71,179.32	25,084.06	0.005	69,597.19	25,622.23	0.007
MUNCIPALITIES						
Carlsbad	34,088.43	20,963.82	0.104	39,398.74	23,632.39	0.095
Lemon Grove	6,335.65	2,837.93	0.026	6,343.13	2,878.31	0.028
La Mesa	24,725.98	5,733.58	0.000	22,676.36	5,979.04	0.000
El Cajon	48,210.63	7,301.16	0.000	49,880.22	7,464.72	0.000
Santee	23,835.32	21,148.86	0.260	27,284.92	21,567.03	0.206
unincorporated	16,937.72	8,503.98	0.046	13,005.85	8,975.84	0.147

Table A6.1. Neighborhood and Municipal Dummy Coefficients from the Condominium Model with Rail Proximity Interactions

	OLS Estimation with Heteroskedastic-Robust Standard Errors Dependent Variable: Condominium Unit Sales Price		
	B	Robust S.E.	SIG
COASTER STATION NEIGHBORHOODS			
Oceanside	251,816.54	47,908.96	0.000
Carlsbad Village	210,222.80	27,641.70	0.000
Carlsbad Poinsettia	Suppressed Category		
Encinitas	312,270.21	46,859.64	0.000
Solana Beach	350,810.93	61,838.87	0.000
NORTH BLUE LINE NEIGHBORHOODS			
Mission San Diego	213,406.43	109,807.60	0.052
Fenton	237,161.63	104,176.82	0.023
Rio Vista	187,575.45	110,449.70	0.090
Hazard Center	210,683.07	109,791.12	0.055
Fashion Valley	221,894.65	107,531.61	0.039
Morena	223,165.59	109,041.28	0.041
Old Town	257,483.47	117,717.73	0.029
Washington	259,135.74	117,218.89	0.027
Middletown	228,510.11	118,728.54	0.054
SOUTH BLUE LINE NEIGHBORHOODS			
8th Street	204,864.19	111,874.76	0.067
24th Street	170,406.56	108,164.24	0.115
Bayfront	236,085.17	99,221.46	0.017
H Street	248,349.97	103,961.57	0.017
Palomar	266,671.13	95,709.84	0.005
Palm	217,613.33	94,355.16	0.021
Iris	239,616.73	92,649.30	0.010
Beyer	233,059.41	92,600.70	0.012
ORGANGE LINE NEIGHBORHOOD			
32nd & Commercial	103,149.00	122,877.42	0.401
47th Street	107,338.57	118,334.10	0.364
Euclid	189,591.42	116,102.34	0.103
Encanto	171,126.99	106,805.34	0.109
Massachusetts	197,567.46	107,649.88	0.067
Lemon Grove	177,503.76	111,622.27	0.112
La Mesa	231,938.13	109,180.69	0.034
Amaya	214,676.83	104,090.84	0.039
El Cajon	196,887.87	97,932.17	0.044
Arnele	210,682.91	94,983.62	0.027
Gillespie Field	203,803.04	102,194.91	0.046
Santee	234,488.62	110,596.32	0.034

Table A6.1. Neighborhood and Municipal Dummy Coefficients from the Condominium Model with Rail Proximity Interactions (continued)

	B	Robust S.E.	SIG
MUNCIPALITIES			
Carlsbad	119,097.65	21,375.98	0.000
La Mesa	-1,730.79	13,115.99	0.895

Appendix B: Expanded Description of the 2SLS Single Family Models with Endogenous Zoning Variables

Table B.1. First Stage Models for Zoning Variables

	OLS Estimation with Heteroskedastic-Robust Standard Errors					
	Dependent Variable: allowable units per acre (units_z1)			Dependent Variable: allowable units on parcel (units_z2)		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
EXCLUDED INSTRUMENTS						
slope_n	0.12	0.13	0.34	0.24	0.03	0.00
slope_n*lot_acre	0.29	0.45	0.51	-1.11	0.19	0.00
slope_n*ln(rail_dis)	-0.69	0.25	0.01	0.04	0.05	0.38
slope_n*lot_acre*ln(rail_dis)	3.09	1.00	0.00	-0.22	0.26	0.40
stfr_tt	1.28	0.77	0.10	0.46	0.21	0.03
stfr_tt*lot_acre	-1.92	2.86	0.50	-1.66	1.10	0.13
stfr_tt*ln(rail_dis)	7.25	1.47	0.00	0.66	0.30	0.03
stfr_tt*lot_acre*ln(rail_dis)	-13.58	5.28	0.01	-0.80	1.39	0.57
trkd_500	8.79	1.20	0.00	1.18	0.23	0.00
trkd_500*lot_acre	-17.06	3.73	0.00	-4.82	1.53	0.00
RAIL PROXIMITY						
ln(rail_dis)	-5.37	1.31	0.00	-0.67	0.22	0.00
PROPERTY CHARACTERISTICS						
str_sqft	0.00	0.00	0.08	0.00	0.00	0.11
lot_acre	1.53	3.42	0.66	15.36	1.43	0.00
lot_acre*slope_p	-0.03	0.18	0.87	-0.01	0.08	0.93
lot_acre*all_emp	-0.37	0.32	0.26	-0.11	0.09	0.23
lot_acre*prewar	-7.51	5.35	0.16	-2.71	4.35	0.53
str_age	-0.09	0.01	0.00	0.00	0.00	0.04
str_age2	0.00	0.00	0.00	0.00	0.00	0.00
baths	0.47	0.18	0.01	0.07	0.03	0.03
beds	-0.37	0.12	0.00	-0.01	0.02	0.52
garages	-0.25	0.11	0.03	-0.03	0.02	0.15
slope_p	-0.03	0.05	0.58	0.00	0.01	0.90
view	0.05	0.16	0.77	-0.02	0.03	0.44
view*coaster	1.30	0.60	0.03	0.20	0.12	0.09
view*ocean	-3.29	4.35	0.45	0.00	0.66	1.00
view*lagoon	1.17	7.37	0.87	3.08	4.47	0.49
pool	-0.10	0.20	0.61	-0.02	0.04	0.59

Table B.1. First Stage Models for Zoning Variables (continued)

	Dependent Variable: allowable units per acre (units_z1)			Dependent Variable: allowable units on parcel (units_z2)		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
NEIGHBORHOOD CHARACTERISICS						
res_land	5.16	4.18	0.22	-0.72	0.49	0.14
hunits_g	-0.91	0.49	0.06	0.01	0.06	0.87
hunits_n	1.28	0.26	0.00	0.13	0.03	0.00
prewar	-6.93	2.66	0.01	-0.52	0.72	0.47
all_emp	0.02	0.14	0.91	0.01	0.02	0.66
fd_emp	1.23	1.17	0.30	0.14	0.18	0.42
pr_emp	-2.72	0.78	0.00	-0.11	0.11	0.33
intrsctn	3.90	1.70	0.02	0.55	0.27	0.04
park_lot	31.01	13.42	0.02	-0.23	1.87	0.90
beach_p	-118.53	23.69	0.00	-12.88	3.47	0.00
open_spc	-1.34	2.21	0.54	-0.66	0.33	0.05
agr_land	-12.84	10.90	0.24	-6.49	2.03	0.00
ocean	12.29	4.86	0.01	1.62	0.70	0.02
lagoon	4.65	7.16	0.52	2.79	3.23	0.39
hwy_500	0.47	0.31	0.13	0.07	0.05	0.17
hwy_1k	0.07	0.24	0.78	0.01	0.04	0.75
bus_500	-0.71	0.22	0.00	-0.12	0.04	0.00
bus_1k	-1.04	0.19	0.00	-0.16	0.03	0.00
COASTER STATION NEIGHBORHOODS						
Oceanside	-0.37	1.32	0.78	-0.29	0.18	0.11
Carlsbad Village	-5.60	2.11	0.01	-0.71	0.64	0.27
Carlsbad Poinsettia	-19.76	2.82	0.00	-1.79	0.72	0.01
Encinitas	-1.64	0.98	0.10	-0.15	0.16	0.34
Solana Beach	-3.76	1.12	0.00	-0.53	0.19	0.01
NORTH BLUE LINE NEIGHBORHOODS						
Qualcomm	-0.03	1.10	0.98	0.18	0.18	0.32
Rio Vista	-9.89	2.21	0.00	-1.06	0.52	0.04
Morena	1.71	1.38	0.21	0.38	0.21	0.07
Old Town	3.14	1.17	0.01	0.57	0.20	0.00
Washington	3.57	1.05	0.00	0.15	0.16	0.35
Middletown	-1.90	1.53	0.22	-0.61	0.21	0.01

Table B.1. First Stage Models for Zoning Variables (continued)

	Dependent Variable: allowable units per acre (units_z1)			Dependent Variable: allowable units on parcel (units_z2)		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
SOUTH BLUE LINE NEIGHBORHOODS						
Barrio Logan	6.58	2.60	0.01	0.53	0.38	0.16
Harborside	2.51	1.98	0.21	0.29	0.26	0.25
Pacific Fleet	3.62	2.01	0.07	0.61	0.27	0.02
8th Street	-7.09	1.44	0.00	-0.67	0.18	0.00
24th Street	-3.92	1.23	0.00	-0.38	0.18	0.03
Bayfront	3.71	1.56	0.02	0.67	0.24	0.01
H Street	-0.30	1.20	0.80	0.24	0.19	0.20
Palomar	-0.80	1.40	0.57	0.13	0.25	0.61
Palm	0.58	1.04	0.58	0.44	0.16	0.01
Iris	1.18	1.07	0.27	0.28	0.16	0.08
Beyer	-1.82	1.04	0.08	-0.07	0.17	0.67
ORGANGE LINE NEIGHBORHOOD						
25th & Commercial	Suppressed Category					
32nd & Commercial	1.88	0.81	0.02	0.44	0.12	0.00
47th Street	2.25	0.97	0.02	0.61	0.15	0.00
Euclid	1.42	0.98	0.15	0.55	0.16	0.00
Encanto	0.77	0.97	0.43	0.34	0.15	0.03
Massachusetts	2.05	1.10	0.06	0.75	0.17	0.00
Lemon Grove	2.16	1.12	0.05	0.74	0.19	0.00
Spring	1.61	1.72	0.35	0.45	0.29	0.11
La Mesa	1.75	1.15	0.13	0.70	0.20	0.00
Grossmont	2.43	1.32	0.07	0.82	0.23	0.00
Amaya	1.80	1.34	0.18	0.61	0.23	0.01
El Cajon	1.53	1.23	0.21	0.47	0.22	0.03
Arnele	-0.42	1.24	0.74	0.05	0.21	0.82
Gillespie Field	3.79	1.38	0.01	0.59	0.26	0.02
Santee	-0.59	2.21	0.79	0.53	0.83	0.53
MUNCIPALITIES						
Carlsbad	6.48	1.89	0.00	0.96	0.59	0.11
Lemon Grove	-0.80	0.25	0.00	-0.28	0.05	0.00
La Mesa	-2.97	0.70	0.00	-0.68	0.14	0.00
El Cajon	1.95	0.74	0.01	0.37	0.15	0.01
Santee	2.73	1.87	0.14	0.15	0.81	0.85
unincorporated	-2.15	1.31	0.10	-0.56	0.24	0.02
constant	0.29	2.60	0.91	-2.34	0.39	0.00
N = 4,866	Test for all variables: F = 77.93, P = .000 R^2 = .5972			Test for all variables: F = 37.60, P = .000 R^2 = .5677		

Table B.2 First Stage Models for Zoning/Rail Proximity Interactions

	OLS Estimation with Heteroskedastic-Robust Standard Errors					
	Dependent Variable: allowable units per acre * rail distance (units_z1*ln(rail_dis))			Dependent Variable: allowable units on parcel * rail distance (units_z2*ln(rail_dis))		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
EXCLUDED INSTRUMENTS						
slope_n	-0.45	0.12	0.00	-0.08	0.02	0.00
slope_n*lot_acre	0.33	0.48	0.50	0.03	0.09	0.74
slope_n*ln(rail_dis)	-0.71	0.34	0.04	-0.08	0.05	0.11
slope_n*lot_acre*ln(rail_dis)	-1.42	1.29	0.27	-0.51	0.24	0.04
stfr_tt	-1.32	0.79	0.10	-0.91	0.17	0.00
stfr_tt*lot_acre	-2.86	2.70	0.29	3.56	0.68	0.00
stfr_tt*ln(rail_dis)	-5.96	2.26	0.01	-2.42	0.38	0.00
stfr_tt*lot_acre*ln(rail_dis)	-8.16	6.65	0.22	8.60	1.27	0.00
trkd_500	-7.69	1.13	0.00	-0.75	0.16	0.00
trkd_500*lot_acre	16.33	4.36	0.00	2.77	0.97	0.00
RAIL PROXIMITY						
ln(rail_dis)	24.34	1.66	0.00	3.68	0.32	0.00
PROPERTY CHARACTERISTICS						
str_sqft	0.00	0.00	0.45	0.00	0.00	0.26
lot_acre	-3.62	2.76	0.19	-4.90	0.80	0.00
lot_acre*slope_p	-0.19	0.15	0.20	0.01	0.04	0.71
lot_acre*all_emp	0.28	0.26	0.28	0.01	0.05	0.79
lot_acre*prewar	3.16	4.64	0.50	-0.23	3.08	0.94
str_age	0.05	0.01	0.00	0.00	0.00	0.51
str_age2	0.00	0.00	0.00	0.00	0.00	0.12
baths	-0.16	0.14	0.26	-0.03	0.02	0.27
beds	0.19	0.10	0.06	0.00	0.02	0.99
garages	0.02	0.09	0.81	0.00	0.01	0.96
slope_p	0.07	0.04	0.05	0.00	0.01	0.67
view	0.20	0.12	0.10	0.04	0.02	0.02
view*coaster	-0.60	0.45	0.18	-0.13	0.07	0.05
view*ocean	-9.66	4.27	0.02	-0.92	0.55	0.10
view*lagoon	-6.89	5.86	0.24	-4.33	1.70	0.01
pool	0.05	0.12	0.69	0.03	0.02	0.17

Table B.2 First Stage Models for Zoning/Rail Proximity Interactions (continued)

	Dependent Variable: allowable units per acre * rail distance (units_z1*ln(rail_dis))			Dependent Variable: allowable units on parcel * rail distance (units_z2*ln(rail_dis))		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
NEIGHBORHOOD CHARACTERISICS						
res_land	-8.16	2.82	0.00	-0.19	0.34	0.57
hunits_g	0.94	0.32	0.00	0.05	0.04	0.18
hunits_n	-0.74	0.17	0.00	-0.07	0.02	0.00
prewar	7.59	2.58	0.00	1.15	0.55	0.04
all_emp	-0.15	0.10	0.15	-0.01	0.01	0.54
fd_emp	1.78	0.83	0.03	0.33	0.11	0.00
pr_emp	2.51	0.60	0.00	0.12	0.08	0.13
intrsctn	-4.05	1.38	0.00	-0.40	0.21	0.05
park_lot	-64.36	19.19	0.00	-4.87	2.40	0.04
beach_p	26.02	20.82	0.21	4.72	2.70	0.08
open_spc	-3.60	1.52	0.02	-0.01	0.20	0.97
agr_land	-4.17	8.20	0.61	-0.92	1.10	0.41
ocean	1.27	4.41	0.77	-0.57	0.53	0.29
lagoon	0.65	5.08	0.90	0.59	0.98	0.55
hwy_500	-0.48	0.26	0.06	-0.03	0.04	0.38
hwy_1k	0.02	0.19	0.90	-0.01	0.03	0.86
bus_500	0.08	0.15	0.59	0.01	0.02	0.71
bus_1k	0.50	0.12	0.00	0.07	0.02	0.00
COASTER STATION NEIGHBORHOODS						
Oceanside	-1.27	1.24	0.31	-0.23	0.18	0.20
Carlsbad Village	0.10	1.73	0.95	-0.58	0.26	0.03
Carlsbad Poinsettia	19.87	2.87	0.00	1.31	0.39	0.00
Encinitas	0.72	0.92	0.44	-0.11	0.15	0.45
Solana Beach	2.20	1.00	0.03	0.07	0.15	0.64
NORTH BLUE LINE NEIGHBORHOODS						
Qualcomm	-0.17	1.02	0.87	-0.34	0.16	0.03
Rio Vista	2.55	0.92	0.01	0.06	0.18	0.74
Morena	-0.32	1.37	0.81	-0.45	0.19	0.02
Old Town	-3.15	0.99	0.00	-0.85	0.17	0.00
Washington	-3.81	0.83	0.00	-0.70	0.15	0.00
Middletown	0.14	0.87	0.87	-0.18	0.15	0.23

Table B.2 First Stage Models for Zoning/Rail Proximity Interactions (continued)

	Dependent Variable: allowable units per acre * rail distance (units_z1*ln(rail_dis))			Dependent Variable: allowable units on parcel * rail distance (units_z2*ln(rail_dis))		
	B	Robust S.E.	SIG	B	Robust S.E.	SIG
SOUTH BLUE LINE NEIGHBORHOODS						
Barrio Logan	-6.14	1.54	0.00	-0.67	0.40	0.09
Harborside	-3.56	1.98	0.07	-0.58	0.24	0.02
Pacific Fleet	-0.34	1.15	0.77	-0.37	0.17	0.03
8th Street	2.53	1.14	0.03	-0.10	0.17	0.53
24th Street	2.49	1.19	0.04	0.07	0.17	0.70
Bayfront	-1.59	1.06	0.13	-0.48	0.17	0.00
H Street	0.29	1.07	0.78	-0.29	0.16	0.08
Palomar	-1.40	1.28	0.27	-0.56	0.24	0.02
Palm	-0.16	0.95	0.86	-0.35	0.15	0.02
Iris	-0.52	1.00	0.60	-0.30	0.15	0.05
Beyer	-0.02	1.02	0.99	-0.32	0.16	0.05
ORGANGE LINE NEIGHBORHOOD						
25th & Commercial	Suppressed Category					
32nd & Commercial	-1.86	0.81	0.02	-0.50	0.12	0.00
47th Street	-0.49	0.84	0.56	-0.44	0.13	0.00
Euclid	-0.22	0.91	0.81	-0.45	0.16	0.01
Encanto	0.05	0.92	0.96	-0.28	0.14	0.05
Massachusetts	-0.23	1.02	0.82	-0.45	0.16	0.00
Lemon Grove	-0.97	1.06	0.36	-0.54	0.17	0.00
Spring	0.34	1.32	0.80	-0.33	0.21	0.11
La Mesa	-0.65	1.04	0.53	-0.55	0.17	0.00
Grossmont	-0.23	1.16	0.84	-0.48	0.18	0.01
Amaya	0.34	1.17	0.77	-0.34	0.19	0.07
El Cajon	1.05	1.09	0.34	-0.25	0.18	0.16
Arnele	1.98	1.12	0.08	-0.03	0.18	0.84
Gillespie Field	-0.86	1.38	0.53	-0.32	0.22	0.16
Santee	-0.54	1.95	0.78	-0.17	0.27	0.52
MUNCIPALITIES						
Carlsbad	-1.13	1.44	0.43	0.08	0.21	0.72
Lemon Grove	0.27	0.20	0.19	0.10	0.03	0.00
La Mesa	0.50	0.48	0.29	0.21	0.08	0.01
El Cajon	-2.27	0.56	0.00	-0.27	0.10	0.01
Santee	-0.95	1.50	0.53	-0.36	0.20	0.07
unincorporated	-1.67	0.86	0.05	-0.02	0.14	0.90
constant	10.55	1.92	0.00	2.35	0.30	0.00
N = 4,866	Test for all variables: F = 134.34, P = .000 R^2 = .7688			Test for all variables: F = 111.32, P = .000 R^2 = .7246		

Table B.3. Joint Tests of Excluded Instruments

	Endogenous, 1st Stage Dependent Variable			
	unit_z1	**unit_z2**	**unit_z1* ln(rail_dis)**	**unit_z2* ln(rail_dis)**
Joint F (SIG)	10.08 (0.0000)	10.94 (0.0000)	22.58 (0.0000)	20.49 (0.0000)
Partial R^2	0.0434	0.0739	0.149	0.1912
Shea Partial R^2, Model 5.A	0.1057	0.1797	n/a	n/a
Shea Partial R^2, Model 5.B	0.1025	0.2157	0.2984	0.4571

Table B.4. 2SLS Test Statistics

	Null Hypothesis	Model 5.A		Model 5.B	
		STAT	**SIG**	**STAT**	**SIG**
Endogeneity (chi-sq) Duban-Wu-Hausman	OLS yields consistent estimates	5.548	0.0624	12.509	0.0139
Overidentification (chi-sq) Hansen J	instruments are uncorrelated with the error term	6.209	0.6209	2.625	0.8542
Underidentification (chi-sq) Anderson canon. corr. LR	equation is underidentified	204.636	0	171.726	0
Weak Identification (F) Cragg-Donald	equation is weakly identified	20.522	<.05	17.163	unknown[115]

[115] STATA does not report the relevant critical values for equations with more than 3 endogenous variables.