VALUE CREATION IN PROXIMITY TO U.S. LIGHT RAIL TRANSIT STATIONS

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ABSTRACT

William L. Bishop: Value Creation in Proximity to U.S. Light Rail Transit Stations
(Under the direction of Roberto G. Quercia, Ph.D.)

A quasi-experimental, longitudinal spatial difference-in-differences, design is employed to estimate differential rates of assessed value creation over time in proximity to light rail transit (LRT) stations. Over the 10-year period from 2005 through 2015, total assessed valuation within ½ mile (but non-overlapping) transit areas of influence (TAIs) surrounding 229 stations, located along 21 light rail transit lines within 14 U.S. transit systems, increased at an average annually compounded rate of 3.13% faster than within surrounding control/comparison areas between 1-mile and 2-miles from stations. Differential rates of assessed value creation varied significantly both within and between transit systems.

Under an alternative definition of treatment areas (wherein all folios within the TAI were counted and attributed to treatment, whether or not treatment areas overlapped) , total assessed valuation within ½ mile (but non-overlapping) transit areas of influence (TAIs) surrounding 22- stations within 13 U.S. transit systems, increased at an average annually compounded rate of 3.21% faster than within surrounding control/comparison areas between 1-mile and 2-miles from stations, or a total of 63% over the period. Differential rates of assessed value creation varied significantly both within and between transit systems.

Unique contributions of this work include quantification of actual differential rates of aggregate annual value creation over time within areas proximate to U.S. light rail transit stations compared to surrounding areas, unlike hedonic price models which estimate consumers'

marginal willingness to pay for amenities such as proximity to transit. The comprehensive nature of the database studied has allowed identification of significant variation in market responsiveness across metropolitan regions as well as within single light rail corridors This variation underscores the importance of individual market and submarket characteristics including timing.

Differential rates of assessed value creation varied widely across transit systems and individual stations. Effects of various station-specific characteristics and transit agency initiatives and objectives on variation in treatment effect across stations were estimated. Differential rates of assessed value creation are found to accrue disproportionately to improvements rather than to land.

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PREFACE

The research reflected in this dissertation is motivated by prior work related to value capture and private sector value creation induced through public investment in light rail transit infrastructure. These subjects appear to be of increasing interest as transit agencies and advocates search for new infrastructure funding sources, and as the federal government considers both significant new infrastructure investment initiatives and strategies for maximizing the value creation and economic development which such investment may induce.

I approach this research with some relevant professional experience and perspective in place. Although I hope that I interpret and grasp the implications of the subject data objectively and with appropriate scientific rigor, I do so through that particular lens framed from within my specific experience. Having spent 30-years as a master-planned community (land) developer, I retain profound and visceral respect for the determinative power of quasi-efficient real estate markets. To the extent I am biased in this regard, it is in the sense I that reflexively perceive "it" [private real estate value creation in this case] to be all about the market. From this perspective, public investment in light rail transit infrastructure is merely one of many intricately interwoven factors defining market opportunity, including the opportunity for private sector value creation.

Land developers embrace the (periodically darkly humorous) refrain that while many perceive determination of land and real property values to be about "location, location, location," it is perhaps more powerfully and accurately about "timing, timing, timing." Clearly timing and location are powerful determinants of market conditions and real estate prices; and the two are somewhat inter-mutable. Time can turn good markets (and locations) into bad ones and vice versa. A very strong location may perform well even in generally weak market conditions under some circumstances, and weak locations may fail or go undeveloped even in very strong markets. These common observations are directly relevant to conclusions derived from the data in this study. The data revealed profound variation in the extent of differential value creation both between markets (transit systems) and across sub-markets (stations within lines/systems). These variations were, perhaps, exacerbated by the fact that data availability dictated that this study span the period of the financial crisis and significant market dysfunction. I may be particularly sensitive to the pervasive impact of these market dynamics because I was personally impacted significantly and adversely by the Great Recession as were many or all of the real estate markets that comprise the subject of this analysis.

Estimation of relative market values (and associated costs) of various alternative amenities and development schemes including matters of design, typology, connectivity, and tradeoffs between public and private goods/realm) is central to the preoccupying strategic thinking (or visceral instinct/reflex) of master-planned community developers. Developers are perpetually weighing and re-weighing "the value proposition." This may be framed, for example, as "*what premium might a mother of school aged children* (very often the home buying decision maker within suburban master-planned communities) *be willing to pay for one type of amenity* (walking trails through otherwise passive parks, for example) *as opposed to another* (a golf course, for example)?" Another relative value consideration might be "what premium might be paid for housing in safe and bicycle/pedestrian accessible proximity to a neighborhood scaled elementary school compared, perhaps, to the discount that might be required of residences in proximity to an out-sized high school?" These often-intuitive considerations of alternative prospective value propositions are all but identical to the retrospective estimation of relative and marginal values derived through the hedonic price modelling discussed herein as background.

Subsequent to my retirement from development, I have provided various consultancy services related to value creation and value capture in connection with light rail transit development. I have also coauthored a guidebook for transit agency officials aimed at maximizing value creation and value capture opportunities associated with transit station development. All of this work has been conceived through a lens of (more or less) free-market economics, and subject to the admonition that it is the market that matters in determining outcomes. Writing now as a planner, I am reminded that to expect any particular outcome in response to planning, or the plans that result, in the absence of market validation, is folly, regardless of how well-intentioned and expertly informed such planning efforts may be.

On May 5, 2017, I was honored to appear before a working group of the Senate Committee on Banking, Housing, and Urban Affairs, Washington, D.C., on the matter of "Innovative Approaches for Measuring and Capturing the Economic Benefits of Public Transportation." I presented preliminary findings of the research reflected herein as well as highlights and recommendations of the "Guide to Value Capture Financing for Public Transportation Projects," recently published by the National Academies of Sciences on behalf of the Transit Cooperative Research Project (TCRP). The round table-like discussion following presentations to the Senate Banking Committee's working group meeting was wide ranging and included: federal transit infrastructure investment strategy and objectives, measurement of induced value creation, strategies and institutional requirements for successful value capture, regulatory and approval processes, workforce and affordable housing (including consideration of housing as infrastructure and as a tool for economic development), economic structural transformation in the U.S. (and globally), and evolving transportation and energy technologies and paradigms. Greater understanding of value creation (in many dimensions) as well as value capture potential is relevant to many of these considerations.

This research follows a number of closely related consulting projects related to finance, value capture, and value creation in connection with GoTriangle's proposed Durham-Orange light rail transit line, Charlotte's Blue Line and ongoing Blue Line Extension, the extension of Boston's Green Line, and private endeavors related to public transit projects elsewhere. This study, like much of my recent work, including a 2015 white paper, "Consideration of Economic Development Potential: Light Rail Transit in Durham and Orange Counties, North Carolina," targets transit agency professionals and others engaged in financing or evaluating transit infrastructure projects.

I hope that this research will contribute in some small measure to a greater and more strongly nuanced understanding of the degree of aggregate private sector value creation that may be induced through public investment in new transit infrastructure, the significant extent to which value creation varies from case to case, and the factors that contribute to that variation.

Notes on scope and methodology

The study originally defined and proposed as the basis of this dissertation was conceived with the understanding that 30 years of assessed valuation data had been compiled and were available through CoreLogic. Additionally, it was thought that the repeat sales data underpinning the Case-Shiller home price index (also owned by CoreLogic) were available at a level of geographic detail that would allow comparison with assessed valuation data over time. Based on this understanding a study of more than 1,100 transit stations over as many as 30 years was proposed.

In fact, CoreLogic maintains only 11 years of assessed valuation data, and does not have the ability to make Case-Shiller repeat sales data available at sub-market levels. Based on the limited data availability, the number of relevant light rail transit stations available to study (based on data-relevant commencement of service dates) was reduced to fewer than 300. This number was further reduced to the 229 stations within 14 transit systems as a result of various data quality issues; these are the subject of this study. Note that several of the subject transit systems include stations on more than one LRT line. Subject stations have been organized within transit systems, denoting both geographical location and transit agency of operation, for the sake of convenience and identification.

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LIST OF ABBREVIATIONS

APTA	American Public Transportation Association
ATE	Average Treatment Effect
BRT	Bus Rapid Transit
CBD	Central Business District
GIS	Geographic Information Systems
LRT	Light Rail Transit
SAD	Special Assessment District
TAI	Transit Area of Influence
TCRP	Transit Cooperative Research Project
TIF	Tax Increment Financing
TID	Transit Influenced Development
TOD	Transit Oriented Development
VC	Value Capture
VMT	Vehicle Miles Traveled

CHAPTER 1: INTRODUCTION

Public investment in infrastructure, such as that required for light rail transit, can induce or facilitate market response resulting in higher rates of private sector value creation than might otherwise have occurred. This study examines the extent of differential aggregate private sector value creation by comparing the private sector value creation (revealed through changes in assessed valuation) occurring within ½-mile of 229 U.S. light rail transit stations to the private sector value creation occurring within surrounding areas over a period extending from 2005 through 2015. The analysis seeks to identify factors contributing to variation in differential rates of value creation and to estimate the significance and magnitude of those affects.

"Value creation" is the principal objective of many economic enterprises. It may be the raison d'être for all for-profit corporations for example. In the context of this writing, "value creation" is any increase in the market value of real property (comprised of land and improvements) resulting from development, redevelopment, renovation, and/or increases in per unit market prices that would result in greater taxable value on an ad valorem basis. The relationship between public infrastructure investment and the subsequent (or anticipatory) private-sector investment it *may* induce is complex and nuanced. Any implication that private-sector value creation, as referred to herein, results directly or exclusively from such public-sector infrastructure investment is unintentional. We do not know, and cannot demonstrate, whether or not differential changes in value creation are due to transit investment, or something else in part or in whole.

"Value Capture" is public recovery of some portion of private property value created, often as a result of public infrastructure investment, through any intentional mechanism.

The extent of differential value creation and factors contributing to variation are of importance because of increasing interest in infrastructure investment in general, and transit infrastructure in particular. Buttressing and perhaps underlying much of the interest in value creation, planners, transit agencies, and financiers and financial advisories are increasingly looking to value capture as a means to fund and finance some part of the significant infrastructure cost associated with transit projects.

Transit ridership within the United States has increased significantly over the past 20-years and has recently been growing at a faster rate than private automobile travel. Virtually all U.S. transit ridership growth has been on rail. The proportion of transit riders on busses has decreased significantly over the same period (APTA, 2015; Newman, 2013). "Light rail has had the fastest growth rate of any mode, almost tripling patronage [albeit from a low starting point] between 1993 and 2011" (Newman, 2013). Increasing demand for public transit, combined with rising infrastructure costs in an environment of modest economic growth and recovery from financial crisis, has amplified financial challenges for transit agencies.

State and local agencies are increasingly looking to value capture to meet escalating infrastructure investment challenges (GAO, 2010; McIntosh, Trubka, & Newman, 2014; Vadali, 2014). Value capture can be one element of increasingly complex and creative "stacks" of capital assembled to finance transit infrastructure, not entirely unlike the complex financings often associated with development of affordable housing (Quercia, Rohe, & Levy, 2000). Value capture is increasingly the subject of consideration as a source of funding for other (non-transportation) public policy objectives such as infrastructure to support compact development and affordable housing (der Krabben, 2008; Rybeck, 2004). Value capture potential is entirely dependent on the underlying private sector value creation that public infrastructure investment can induce. Anticipating where and to what extent such value creation will occur is complicated by the fact that both the volume of new transit ridership and the magnitude of value creation in response to new light rail transit infrastructure varies significantly both across and within metropolitan markets. Not only do underlying economic and market forces play significant roles in determining private sector response to public sector investment, but market conditions and opportunities fluctuate significantly with market and economic cycles.

Value capture and transportation infrastructure investment in the U.S.

Although this study does not address value capture per se, value capture provides both context and motivation for this value creation analysis. Value capture refers to a range of mechanisms and strategies designed to recover some of that private sector value creation induced by public investment in transportation (or other) infrastructure which is capitalized into real property values. Within the context of fixed guideway transit, value capture opportunities arise from value created within the transit-oriented development (TOD) and/or otherwise transit-influenced development (TID) that can result in proximity to transit stations. Value associated with the transit service and accessibility, as well as that of other amenities common to development occurring in proximity to transit stations may become capitalized into the market price of real property (Cervero, 2004; McIntosh et al., 2014). Understanding the magnitude of such value creation, and the extent to which some portion of that value constitutes a market premium to transit, is increasingly important to those looking to value capture as a means of financing some portion of transit (or other transportation) infrastructure investment.

Public investment in transit infrastructure can attract and induce additional public and private investment resulting in private (real estate) value creation. Some part of that value may be captured and reinvested in yet additional accessibility, thus inducing potential for yet more value creation. This can establish a virtuous cycle of increasing demand, reinvestment, and value creation (Cervero & Aschauer, 1998; Curtis, Renne, & Bertolini, 2009; Dittmar & Ohland, 2004;

Tan, Janssen-Jansen, & Bertolini, 2014). Such a virtuous cycle is illustrated in *Figure 1*[1]. Investment in (capacity and accessibility creating) transit infrastructure by transit agencies, federal, state, and local government, and other public-sector actors can induce private sector investment, development, and value creation.

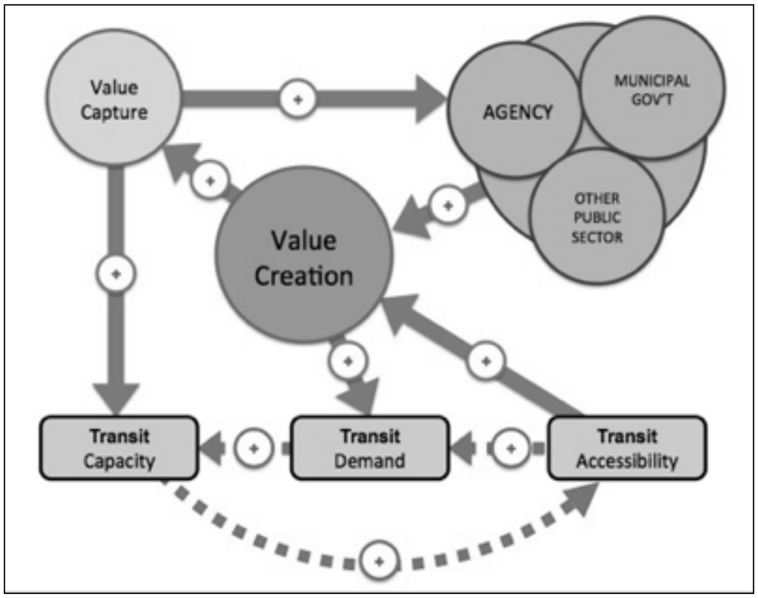

Figure 1: Virtuous cycles of value creation

Some part of any such value creation may be captured by public sector investors both to recoup investment and to invest in additional transit capacity. Subject to adequate unsatisfied demand for transit, increased capacity provides improved accessibility and ridership (as well as ancillary market demand and activity) inducing additional value creation. Such value creation may include a variety of urban amenities, such as those often embedded in transit-oriented development, that further spur demand, and so on. Such virtuous cycles of investment, value creation, value capture, reinvestment, and expansion of value-inducing capacity are possible because some part of the value of enhanced mobility, accessibility, and other prospective amenities can become capitalized into nearby land, commercial real estate, and housing prices (Agostini & Palmucci, 2008; Golub, Guhathakurta, & Sollapuram, 2012).

Notwithstanding the great potential for such value creation, and the potential for value capture to offset public investment in transit infrastructure, results within the U.S. have been

[1] Figures 1 through 3 are adapted from Guide to Value Capture Financing for Public Transportation Projects.

mixed and often less than uniformly satisfactory both with respect to value creation and to value capture. In response, the Transit Cooperative Research Program (TCRP), an applied, research program that develops near-term, practical solutions to problems facing transit agencies, recently sponsored development of the *Guide to Value Capture Financing for Public Transportation Projects* recently published by the National Academies Press (2016).

> Value capture is the public recovery of a portion of increased property value created as a result of public infrastructure investment. Common value capture mechanisms are impact fees, joint development, sale or leasing of air rights, land value taxation, station naming rights, negotiated exactions, parking fees, sales tax and special assessment districts (SADs), and tax increment financing (TIF). Given expanding demand for new transit infrastructure and scarce financial resources, U.S. transit agencies are increasingly looking toward innovative funding sources and strategies. Value capture is one of these innovative strategies (Page & Bishop, 2016).

Measuring transit-induced value creation

Capitalization effects, the extent to which the value of transit accessibility and/or other transit proximity related amenities or benefits become capitalized into the market price of real property, may be either positive or negative. Proximity to light rail transit stations may increase property values because of enhanced mobility and accessibility as well as proximity to other amenities. On the other hand, proximity to rail lines further removed from station area may decrease property values because of nuisance effects and negative externalities such as noise, vibration, and other environmental impacts (Armstrong & Rodriguez, 2006; Golub et al., 2012).

> The literature on land and property values demonstrates a great deal of variability in the estimated change in values arising from rail investments… a meta-analysis on empirical estimates from 23 studies that analyzed the impact of rail on land/property value changes… show that a number of factors produce significant variations in the estimates. These include the type of land use, the type of rail service, the rail system life cycle maturity, the distance to stations, the geographical location, accessibility to roads, methodological characteristics, as well as whether the impacted area is land or property (Mohammad, Graham, Melo, & Anderson, 2013).

This study contributes to a growing body of literature regarding value creation induced through proximity to light rail and/or other transit stations within transit-oriented development (TOD) or within otherwise transit-influenced development (TID). Unlike hedonic price models which estimate consumers' marginal willingness to pay for amenities such as proximity to transit, this study quantifies actual differential rates of aggregate annual value creation within areas proximate to U.S. light rail transit stations compared to surrounding areas. Additionally, this study contributes to an understanding of the impact on value creation of station characteristics and transit agency implementation strategies. These include 1) early engagement by transit agencies in strategic public-private partnership, 2) station location in terms of development typology, 3) dominance of pedestrian or vehicular design, and 4) employment of specific value capture strategies.

Transit-oriented and transit-influenced development, and value creation

Much of the literature relating to value creation and value capture has focused on attributes of transit-oriented development in addition to the value-related effects of transit capacity and accessibility. The viability and success of value capture strategy within TOD and TID is explicitly dependent on the extent of differential value creation, as well as other institutional, economic, market, and financial factors. While "it has long been recognized that fixed transit infrastructure creates urban value in the property and land markets" (Cervero & Kang, 2011; Rodríguez & Targa, 2004; Smith & Gihring, 2006), "there [have been] few comprehensive assessment frameworks used to assess and capture the benefits…created" (McIntosh, 2015). Any such value capture assessment framework is dependent on an understanding of the extent of value creation potential, and the factors that affect value creation.

Extensive research has been conducted regarding institutional and inter-institutional factors such as the need for coordination between urban land use and transportation planning, with particular emphasis on transit-oriented development. The need for such coordination may be particularly acute in the context of TOD, transit-influenced development, and value capture opportunity where many actors must cooperate to realize optimal outcomes.

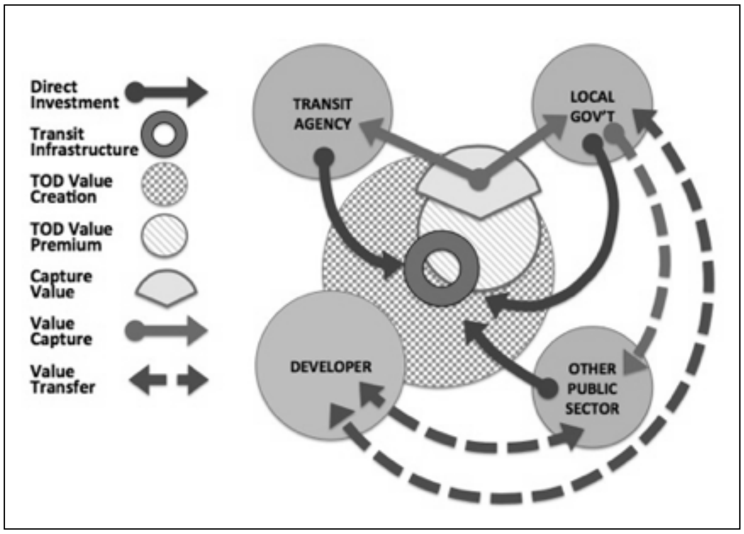

Figure 2: Investment, value creation, value capture and transfer

Figure 2 illustrates the idea that once new direct investment in transit infrastructure is effected through a transit agency (or equivalent) private sector developers (and investors and speculators) *may* respond in a manner that creates or otherwise results in value creation surrounding that infrastructure. In many cases, some portion of that value creation can be construed as value premium in the sense that land or other real estate assets command higher prices (value) than would be the case in the absence of the infrastructure investment. Any such value premium creates opportunity for the public-sector investor(s) to capture some part of that value to provide a return on or a partial return of the public investment. So long as the extent of value capture does not exceed the infrastructure induced premium, such a revenue source (exaction) should not create a competitive disadvantage in the market.

Value capture might be used to return revenue to other public entities such as local government which may have invested (directly or indirectly) in transit supportive municipal infrastructure. Value capture benefits (revenue) realized by local government may be used both to invest in other public policy objectives (such as affordable or workforce housing for example) and/or to provide additional value creating incentives to developers (infrastructure related impact fee credits or offsets for example).

Effective value capture strategy can buttress a virtuous cycle of value creation (Huxley, 2009; Levinson & Istrate, 2011). The potential for and extent of value creation within TOD may be dependent, in part, on the extent of cooperation and strategic engagement between transit agencies, local government, other public-sector agencies and interests, private landowners and developers, and other private sector interests, as depicted in *Figure 2*[1]. Transit agencies seeking to benefit from value capture following direct investment in new transit infrastructure must rely on the cooperation and engagement of private developers and local government in providing additional investment and negotiating market appropriate value-optimizing entitlements. Developers and local governments may also cooperatively engage with other public-sector actors such as housing authorities to participate in additional value-creating investment. The engagement referred to here is not merely that which is often undertaken in the interest of balancing multiple interests toward the end of building consensus or acceptance (Kaza, 2006), but that which is required to align strategic interests in long-term value creation, particularly in the context of unknowable future economic and market conditions (Zapata & Kaza, 2011). The extent and complexity of cooperative and strategic engagement required of multiple public and private actors, each constrained by market forces and requirements of public or private finance, is illustrated in Figure 3[1].

Experience suggests that frequent institutional reluctance to engage in strategic partnership toward mutually beneficial TOD/TID value creation may result from cultural,

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[1] Figures 1 through 3 are adapted from Guide to Value Capture Financing for Public Transportation Projects.

institutional, administrative, and legislative forces as well as divergent market and non-market incentives (Kaza, 2013). The institutions and parties that must cooperate in the interest of maximizing value creation often operate from within largely isolated silos of language, perspective, and vision.

Disinclination or reluctance to engage, cooperate, and plan and act together may result from failure to recognize mutual benefits, and from very different understanding of the meaning of plans themselves (Kaza, 2008). Overcoming such reluctance may require a more thorough understanding of the nature and scale of potential benefit to all parties resulting from both inter-institutional engagement, and in realization of significant incremental value creation through joint planning and joint or coordinated action. Transit agencies and other public-sector actors may benefit from a more thorough understanding of the tools and requirements necessary to achieve such value creation (Kaza & Hopkins, 2007). Transit agencies may forgo beneficial strategic partnership and market engagement in favor of laissez-faire reliance on the presumption that market response to new or enhanced transit infrastructure investment and services will result in desired value creation. Real estate price premiums sometimes associated with TOD/TID are frequently generalized and interpreted as proxy for value creation in the aggregate. Figure 3 illustrates the sort of strategic engagement and/or partnership required to maximize private-sector value creation in response to public-sector infrastructure investment.

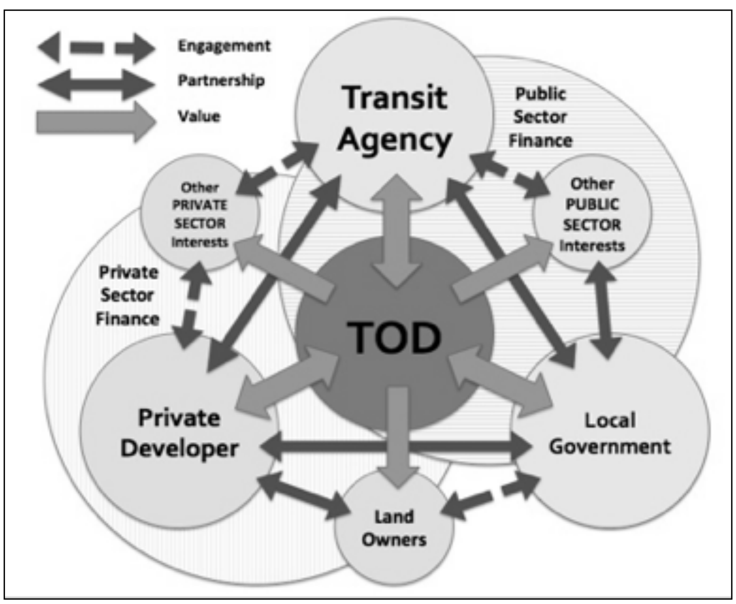


Figure 3: Inter-entity engagement and strategic partnership

Transit agencies, other public-sector agencies, and private-sector both invest directly in value creation and stand to benefit (participate) in such value creation either directly or through value capture. Strategic engagement, if not formal partnership, between these entities is required to maximize the value creation opportunity. The nature of such partnership or engagement is constrained by the requirements and peculiarities of the (dynamic) public or private finance environments in which they operate. Land owners, speculators, and investors, and other public-sector entities may benefit from value creation even if they do not invest in it. Notwithstanding this, significant benefit may result from strategic engagement between primary public and private sector actors and other stakeholders. Thorough understanding of the causes, requirements, nature, and extent of transit infrastructure-induced value creation is both currently inadequate and desirable.

Quantifying effects of proximity to light rail transit stations on assessed valuation over time

This analysis seeks to test the hypothesis that proximity to light rail transit stations resulting from public infrastructure investment results in higher rates of development and aggregate value creation than occurs over the same periods of time in locations further removed from transit stations. We have long observed that facilities providing for transportation of people and goods to and from fixed geographic locations induce investment in transportation-supportive and other infrastructure and result in concentrations of commercial activity. This has been true of harbors, seaports, the mouths and confluences of rivers and navigable waterways, rail junctions and termini, as well as Interstate and other highway junctions and interchanges. Similarly, research has identified value creation effects associated with bicycle and pedestrian trail facilities as with conventional surface transportation infrastructure (Song, 2002).

The tendency for people to congregate, and for commerce and other human activity to become concentrated, in centers or nodes of high activity where transportation has been facilitated (and where direct transportation - or commuting - costs have been minimized), and for land rents to increase with density and activity, is consistent with theories of urban spatial structure (Alonso, 1964; Muth, 1979). Both economic theory and many hedonic price models extant in the literature suggest that consumers who would benefit from living and/or working, shopping, or recreating in proximity to transit stations should be willing to pay for such proximity. Such willingness to pay for accessibility should create economic opportunity for those who would provide (develop) residential, office, retail, and other real property improvements in proximity to transit, when and where the value of those (consumer preferential) price premiums exceed the cost(s) associated with supplying the amenities and specific bundles of goods demanded by consumers.

Although assessed valuation is a somewhat sluggish and imperfect measure of underlying market value in real time, it is a useful and important measure of value for purposes of implementing many value capture strategies and for considering related public policy objectives. Methodologies associated with value assessment for ad valorem tax purposes present several concerns (particularly with respect to assessed valuation as a real-time proxy for market value). These concerns are addressed under “Limitations” below. Assessed valuation reduces or eliminates other concerns, however, such as sample selection biases within price indices (Jud & Winkler, 1999), and provides a number of practical advantages.

> One attractive feature of the assessed-value method is the ability to efficiently incorporate property- and location-specific information from potentially every single … property that exists in a location as a data point. In addition, we appreciate that an expert assessor may be able to capture value adjustments not typically measured by the set of explanatory variables used in a standard hedonic type of estimation…In addition, the comprehensive nature of the database allows us to segment the data by value or geographical region and compare the price changes (Gatzlaff & Holmes, 2013).

This analysis quantifies differential annual rates of change in assessed value and folio density between areas of treatment (immediately proximate to stations) and surrounding areas (control) for 229 light rail transit stations along 21 LRT lines in 14 U.S. transit systems between 2005 and 2015, and evaluates a number of station-specific, transit agency, and demographic characteristics in an effort to explain variation in differential value creation. Note that several of the subject transit systems include stations on more than one LRT line.

Effect of station-specific characteristics and transit agency initiatives on variation in differential rates of light rail transit influenced value creation

Differential rates of value creation within transit (station) areas of influence vary significantly both between transit lines and markets as well as within the same transit line. This analysis seeks to identify the extent to which specific station characteristics are associated with variation in differential rates of value creation. Specific station characteristics include station design (e.g. elevated, at grade, open cut, underground, etc.), dominant station character (e.g. walk-and-ride or park-and-ride), the number of parking spaces provided at each station, and a range of station locational typologies (e.g. downtown – Central Business District (CBD), urban center, urban neighborhood, suburban town center, suburban neighborhood, campus, entertainment, special).

Value creation (and any potential for subsequent value capture) is influenced by other factors as well. Robust value creation is dependent on a number of requisites including:

> real estate market vitality, accommodative zoning and land use entitlements; and development of project- and context-specific financial strategies that are feasible and incentivize and reinforce value creation; and institutional capacity on the part of transit agencies, local governments, developers, and other partners working together to maximize value creation and value capture" as represented in *Figure 4* (Page & Bishop, 2016).

Economic conditions fluctuate significantly over time. Real estate market conditions vary from time to time and place to place. Market conditions specific to each metropolitan market are captured within Transit System designation. Responses to transit agency survey questions (described below) address 1) the extent of public-private engagement [represented as *Public-Private Enterprise* arrow in Fig. 4], 2) institutional capacity, and 3) regulation regarding value capture to some degree. Although institutional capacity and regulation affect value capture potential more directly that value creation, they may inform the extent to which transit agencies are focused on maximizing value creation early and strategically.

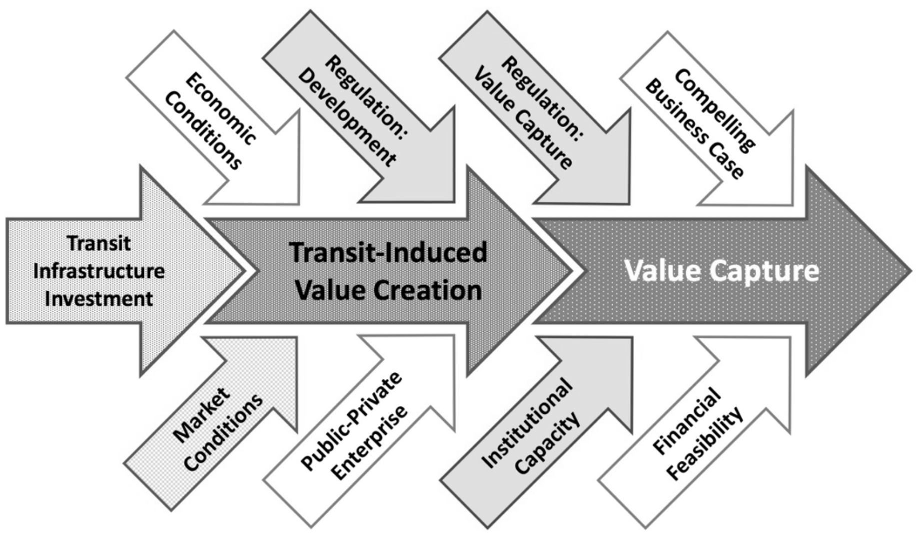


Figure 4: Conditions precedent to value creation and capture, Adapted from Guide to Value Capture Financing for Public Transportation Projects

This analysis seeks to identify the extent to which specific transit agency objectives and initiatives are associated with variation in station-specific rates of differential value creation over time. Surveys were solicited from senior planners and managers from the 14 transit agencies represented in this study. Survey respondents were asked to classify stations within standardized design, locational, and functional typologies. In addition, respondents were asked to provide background on transit line project and planning objectives, initiatives related to value creation and value capture, strategic engagement with entities outside the transit agency, and the relative importance of various initiatives to achievement of transit (i.e. planning and investment) objectives.

Brief summary of findings

Differential rates of assessed value creation varied widely across transit systems and individual stations. Where treatment areas were defined such that there was no overlapping of adjoining treatment areas, Transit Areas of Influence (TAIs) in the top 20% of differential value creation experienced average annual growth rates 30.67% faster than that of control, whereas TAIs in the bottom quintile experienced negative average annual differential growth rates (1.25% less than those within control areas). Significantly positive differential value creation was concentrated within a small number of transit systems and within a relatively few number of stations along several of the lines studied.

Differential rates of assessed value creation are found to accrue disproportionately to improvements (and to folio density) rather than to land. In the aggregate, assessed improvement(s) values grew 4.35% faster in treatment areas than in control areas, whereas assessed land values grew only 3.28% faster within treatment areas. The extent to which treatment explained variation in differential value creation was roughly twice that for assessed improvement(s) value and that for assessed land value (approximately 2% compared to approximately 1%). Additionally, although the treatment-time interaction effects were significant over the entire period for assessed improvement values, the effect was not significant in any individual year for assessed land value.

Significant covariates included transit system (location), accounting for 19% of the differential rate of change in total assessed value per acre over time; per capita income (at the census block-level), accounting for an additional 3% of variation; station design, accounting 2% of variation; transit agency perceptions of public-private value creation strategies as important 1) to the success of transit infrastructure investments and projects, and 2) to the success of transit-influenced or transit-oriented development, accounted for an additional 1% of variation each. Significantly positive differential value creation occurred predominantly near at-grade stations.

Of numerous demographic covariates evaluated, only per capita income and vehicles per household were significant, predicting 4% and 2%, respectively, of the variation in differential rates of change over time (the interaction of covariate and time) between treatment and control groups.

Where treatment areas were defined such overlapping of adjoining treatment areas was allowed, differential rates of assessed value creation per acre were similarly highly varied across transit systems. Differences between compounded annual rates of value creation within treatment and control areas ranged from -1.16% to 7.82% (3.21% average across all stations, regardless of system).

Contribution to literature and practice

This study attempts to bridge some part of the gap between the generally accepted understanding of potential for transit price/value premium (i.e. some consumers willing to pay price premium to live/work in proximity to transit-oriented development, under certain circumstances), and a larger understanding of differential light rail transit induced value creation in the aggregate. This distinction may be important and useful to policy makers deciding when and where to make infrastructure investments or how to maximize the realizable value of those investments; transit professionals seeking to lay the groundwork for optimal value creation and/or value capture; and financiers undertaking to finance such investments. Many transit professionals, and other advocates of public transit in general and/or LRT, may be enticed by the notion that investment in new light rail transit capacity and stations can result in transit value premiums capitalized into real estate value. This premium (consumers' willingness to pay, realized in some locations during some periods under certain circumstances) may become conflated with the aggregate value creation on which policy makers and financiers must rely in order to realize value capture as a viable source of infrastructure finance. The fact that specific markets or sub-markets may respond to new LRT stations with significant apparent price premiums may become misinterpreted as an indication that such market responses occur spontaneously and/or more or less uniformly. This may devolve into a sense and expectation that "if we build it they will come," setting up disappointment when value creation fails to materialize uniformly or robustly.

This study spans those years that were significantly and adversely impacted by the Great Recession. It appears that market forces and characteristics other than those captured within the covariates in this study influence differential value creation in proximity to new light rail transit systems to a significantly greater extent than the treatment (i.e. new infrastructure/investment) itself. This underscores the importance of understanding and underwriting such market condition and factors before undertaking projections with respect to anticipated levels of value creation.

This study is intended to inform public policy and professional practice in the U.S. with respect to planning for and realizing value creation, particularly in the context of prospective investment in new LRT infrastructure. Policy considerations may include not only the question of whether to invest in new transit infrastructure along a particular alignment in a particular place at a particular time, but what transit technology is optimal. The question of transit mode/technology involves not only its effectiveness and utility as transportation, but its capital and operation costs both before and after consideration of potential value creation and value capture, and its potential to induce economic development. Light rail transit may not be the low-cost transportation solution in all settings. Justification of the significant capital investment required of LRT may require reliance on significant value creation and related fiscal impact and economic benefits. A more thorough and context-specific understanding of the nature and causes of light rail transit-induced value creation is desirable.

CHAPTER 2: LITERATURE REVIEW

That growth in real property value in which policy makers and financiers of public transit infrastructure are interested occurs over long periods of time and must be stable and enduring. Its conditions precedent must be well understood. Policy makers, planners, and financial advisories and underwriters must be able to anticipate with some confidence when, where, and to what extent value will be created in response to new infrastructure investment.

Dominant themes in the literature suggest that although uneven, consumers are generally willing to pay some price premium for real estate proximate to light rail or other transit stations (including Bus Rapid Transit, or BRT) and/or within transit-oriented or transit-influenced development. Some studies have suggested that consumers' revealed willingness to pay a price premium may be related as much to a specific range of urban and lifestyle amenities as to transit accessibility; whether or not those amenities are located near transit stations. Most of these studies have employed hedonic price models to disaggregate consumer preferences for various individual characteristics of highly heterogeneous properties; which characteristics are not traded individually in the marketplace. Some discussion of hedonic models follows within this literature review, as does review of literature addressing appropriateness of assessed valuation as a measure of value.

Many studies have been undertaken to estimate the real property value effects of proximity to light rail (and other) transit stations. (NEORail, 2001) There have also been extensive reviews of this literature (Cervero & Aschauer, 1998; Cervero, Ferrell, & Murphy, 2002; Garrett, 2004; Huang, 1996; Landis, Guhathakurta, Huang, Zhang, & Fukuji, 1995). Research has generally identified positive, but varying and uneven, real property value impacts associated with proximity to LRT stations. Some studies have identified no positive impacts, and others have identified negative impacts. A 2012 study, Evaluating the Economic Impacts of Light

Rail by Measuring Home Appreciation: A First Look at New Jersey's River Line, found that "the net impact of the line on the owned housing market is neutral to slightly negative. While lower-income census tracts and smaller houses seem to appreciate near the station, this may be a value transfer from farther-away properties not favored with access" (Chatman, Tulach, & Kim, 2012). A 1993 study of the impact of the Miami Metrorail system on residential property values proximate to stations employed repeat-sales indices and hedonic regression methods and found that "residential values were, at most, only weakly impacted by the announcement of the new rail system." (Gatzlaff & Smith, 1993) Other studies have found positive value impacts in proximity to stations, but offsetting negative value impacts near transit lines outside of station areas (Armstrong & Rodriguez, 2006; Bowes & Ihlanfeldt, 2001).

The 2013 Mathur and Ferrell study concludes that "in general the empirical evidence suggests that proximity to the station and increase in overall transportation accessibility increase home prices." Notwithstanding this, results of value creation and transit premium studies have been inconsistent and somewhat contradictory. This should not surprise. Anecdotal experience suggests that market response to new LRT station development has been robust in some instances and underwhelming in others. The 2009 Mineta Transportation Institute Report on the Effect of Transit Oriented Developments (TOD) on Nearby Home Values, also written by Mathur and Ferrell, "estimates the impact of four San Francisco Bay Area sub-urban [rail transit] TODs on single-family home sale prices. The study finds that the case study suburban TODs either had no impact or had a positive impact on the surrounding single-family home sale prices." (Mathur & Ferrell, 2009).

This literature review is comprised of several sections. The first focuses on literature addressing value creation and the transit premium. A subsection focuses on literature employing hedonic price models. Much of the research in this area has employed hedonic regression while other studies have employed matched-pair or repeat sales ratio analyses. All of these approaches attempt to control for characteristics other than proximity to transit in highly heterogeneous individual real estate properties. While there may be problems with any approach, hedonic models are commonly perceived to impose the most rigorous controls and are used most widely (Cervero & Aschauer, 1998).

The second section focuses on literature related to transit-oriented development (TOD) and value creation. The summary section reviews the literature in the context of the specific aims of this dissertation, and its three research objectives: 1) quantifying effects of proximity to LRT stations on assessed valuation, 2) consideration of station-specific characteristics and transit agency initiatives, and variation in differential rates of LRT-influenced value, and 3) identification of background demographic characteristics predictive of variation in differential rates of LRT influenced value creation.

Light rail transit value creation and the value premium

Numerous studies have been undertaken over several decades regarding the relationship between light rail transit and property values. Analyses have employed a wide range of methodologies and measures of value. An extensive body of literature estimates the effect of proximity to the rail station (Bajic, 1983; Benjamin, 1996; Cervero & Duncan, 2002c; Cervero & Landis, 1997; Chatman et al., 2012; Hess & Almeida, 2007; Lewis-Workman & Brod, 1997; Rodriguez & Mojica, 2008; Strand & Vågnes, 2001), transit lines (Dubé, Des Rosiers, Thériault, & Dib, 2011; Nelson, 1992), and the effect of transportation accessibility on property values (Armstrong & Rodriguez, 2006; Cervero, 2004; Gatzlaff & Smith, 1993; Mathur, 2008; Voith, 1993; Weinberger, 2000).

Additional examples of studies of the relationship between light rail transit and property values undertaken within the U.S. and globally include: Perth, Australia (Nurlaela & Pamungkas, 2014); Phoenix, Arizona (Golub et al., 2012); Minneapolis, Minnesota, Denver, Colorado, and Charlotte, North Carolina (Fogarty & Austin, 2011); Guangzhou (Canton), China (Tian, 2006); The Netherlands, (Debrezion, Pels, & Rietveld, 2011); Sunderland, UK (Du & Mulley, 2007); Atlanta, Georgia (Bowes & Ihlanfeldt, 2001; Nelson, 1992); Dallas, Texas (Weinstein, Clower, Means, Gage, Pharr, Pettibon, & Gillis, 2002); Miami, Florida (Gatzlaff & Smith, 1993); Queens, New York (Lewis-Workman & Brod, 1997); Philadelphia, Pennsylvania (Voith, 1993); Portland, Oregon (Al-Mosaind, Dueker, & Strathman, 1993; Chen, Hu, & Zhou, 2011; Dueker & Bianco, 1999); Sacramento, California (Landis et al., 1995); San Diego, California (Cervero & Duncan, 2002b; Landis et al., 1995); Los Angeles, California (Cervero & Duncan, 2002a); San Francisco, California (Landis et al., 1995; Lewis-Workman & Brod, 1997); San Jose, California (Cervero & Duncan, 2002c; Landis et al., 1995); Santa Clara County, California (Cervero & Duncan, 2001); St. Louis, Missouri (Garrett, 2004); Chicago, Illinois (McDonald & Osuji, 1995); and Sheffield, England (Henneberry, 1998).

In addition to value expressed exclusively in terms of market value, some of these studies focus on the nature, quality, and caliber or density of development that may be induced through investment in new transit infrastructure, and the value impact of specific characteristics of place. Many value studies have been cross-sectional in nature. Few of the longitudinal studies consider extended periods of time. Much of the existing literature employs or concerns the results of hedonic price models.

Hedonic price models

Three approaches have commonly been employed to isolate and identify transit-induced effects on real property values. These include matched pairs, repeat sales, and hedonic price models. Matched pair studies are those where units of observation (properties) sharing as many characteristics as possible (except for the one under investigation – proximity to LRT stations in this case) are paired for purposes of comparing effects of the single differentiating characteristic. The repeat sales method of measuring changes in real property values over time involves comparing transaction prices of those individual properties that have changed hands multiple times over the subject time period. Perhaps the best-known example of repeat sales analysis is the Case-Shiller Index which relies on that method.

The most common of these approaches is the hedonic price model. Many hedonic price models have been developed since the 1970s to isolate market price response to specific real property attributes such as proximity to LRT systems (Kittrell, 2012). These models estimate consumers' marginal willingness to pay for some particular attribute, holding individual characteristics and all other factors constant (Rosen, 1974). Hedonic price models employ multiple regression analyses to disaggregate and apportion real estate prices to individual explanatory variables, estimating the marginal contribution of each to total market price.

The literature comprised of hedonic price models estimates the market price effect of proximity to LRT or other transit stations such as those for BRT or proximity to TOD—or some subset of TOD amenities—on a single class of individual residential or non-residential properties as the unit of observation (Rodríguez & Targa, 2004). These studies have generally been cross-sectional or of limited duration (often comprising two time periods), sometimes spanning commencement of new transit service. In a paper by Cervero and Duncan, for example, select observations for commercial, office, and light industrial properties for 1998 and 1999 "were … felt to provide a sufficient time lapse for the benefits of proximity to light and commuter rail services [introduced in the early 1990s] to have taken [effect]" (Cervero & Duncan, 2001).

A 2010 study of LRT value effects on single family homes in Phoenix, Arizona found that predominantly walk-and-ride communities experienced premiums of 6 percent for single-family houses and over 20 percent for condos, the latter boosted an additional 37 percent by overlay zoning. Whereas predominantly park-and-ride communities experienced no capitalization benefits for single-family houses and a discount for condos (Atkinson-Palombo, 2010).

A 2011 review of literature reporting hedonic price model estimates of TOD impacts on real estate values, "confirms that the market shift is, indeed, being capitalized into real estate prices and demonstrates that the amenity-based elements of transit-designed development play an important positive role in urban land markets, independent of the accessibility benefits provided by transit" (Bartholomew & Ewing, 2011).

Representative examples of such studies include those for markets such as: San Diego, California (Duncan, 2010); Phoenix, Arizona (Kittrell, 2012); Los Angeles County, California (Cervero & Duncan, 2002a);San Diego County, California (Cervero & Duncan, 2002b); Manchester, England (Forrest, Glen, & Ward, 1996); Multiple markets, California (Landis, Guhathakurta, & Zhang, 1994); Commercial properties (Weinberger, 2000); Santa Clara, California (Weinberger, 2001); Subway impacts, Toronto, Canada (Bajic, 1983; Dewees, 1976); Buffalo, New York (Hess & Almeida, 2007); Subway impacts, Seoul, Korea (Bae, Jun, & Park, 2003); Miami, Florida (Gatzlaff & Smith, 1993); Guangzhou, China (Tian, 2006); Portland, Oregon (Al-Mosaind et al., 1993; Chen, Rufolo, & Dueker, 1998); and Oslo, Norway (Strand & Vågnes, 2001).

Hedonic price estimates are commonly employed in part because "there is a consensus in the housing literature that the hedonic price method offers the best econometrics environment to estimate housing prices" [as a function of value influences such as proximity to transit] (Haider & Miller, 2000). Hedonic price studies have been useful in estimating the implicit market value of amenities (such as accessibility/proximity to transit, walkability, and other aspects of TOD), which are not explicitly and discretely traded in the marketplace. Such price (only) effects may not be sufficient, however, to inform understanding of the extent of aggregate value creation within TOD or in proximity to new LRT stations and service. It is conceivable, for example, that higher unit prices could come at the expense of quantity or velocity of sales, or that relatively high residential density and price could displace office or retail space of higher value.

Hedonic price estimates do not translate simply and directly into estimates of aggregate value creation within a transit area of influence, nor into comparison of that aggregate value to areas beyond transit influenced development. Consumers' willingness to pay a premium for proximity to TOD or proximity to transit in some other form of transit-influenced development may come at the cost of unit size and/or other amenities. Those willing to pay a market premium for proximity to transit (within the context of a hedonic price model) may elect to purchase or lease relatively small units at relatively modest levels of fit and finish in order to be able to afford the transit price premium. Knowledge of such consumers' willingness to pay a transit premium is potentially useful for market niche-seeking developers, investors, lenders, and marketers, but less so for policy makers and transit financiers interested in aggregate value creation, prospectively in the interest of value capture.

Numerous hedonic price models have estimated the implicit value of proximity to transit stations, as well as that of TOD attributes and amenities. Such estimates are useful and informative with respect to disaggregating and estimating consumers' marginal willingness to pay real estate price premiums for properties benefitting from proximate transit (and/or other) amenities. Such estimates may be insufficient, however, to inform decisions regarding investment in value capture-optimizing value creation strategies. Any such inadequacy may induce opportunity cost resulting from failure to engage early and effectively in strategic public-private partnership, coordination of value creation across and between station sites, and planning for and optimization of value capture opportunities. An "if we build it they will come – and create value" presumption on the part of transit planners and managers may discourage the very activism and early strategic engagement necessary to lay the ground work for value capture and the value creation on which it depends. Contributing to the potential opportunity cost of incomplete knowledge with respect to value creation is limited understanding of the relative contributory value effects of TOD/TID typology, dominance of walk-and ride or park-and ride characteristics, and implementation of various value creation and value capture strategies. Existing literature reveals that the potential for LRT and TOD value creation and price premiums, while generally positive, is highly inconsistent, as is also the case for other modes of transit such a BRT (Rodriguez & Mojica, 2008). Both the "magnitude and direction of property value impacts [can] vary" based on a number of characteristics (Mathur, 2014).

Hedonic price models estimate consumers' willingness to pay a marginal price differential for a specific amenity or characteristic (of highly heterogeneous products or services such as housing) adjusted for many other characteristics. The hedonic model reveals otherwise ambiguous preference, but neither consumers' ability to pay a particular price in total, nor the extent to which such preference might result in increased total price/value or value creation. The hedonic price model does not tell us when or where proximity to transit may result in additional realizable demand or development. Consumers within a specific demographic may have a very strong preference for travel via public transit and be willing to pay a premium to live in proximity to transit stations. If income constraints are such that apparent price premiums for transit accessibility must be offset by reductions in unit size, construction quality, fit, and finish, and/or other amenities so as to achieve affordability, it is not clear that consumers' willingness to pay for transit accessibility will always induce positive differential value creation—or in value creation at all. This depends on who the transit accessibility-preferring consumers are, their other (non-transit) preferences, and their willingness and ability to pay a total (aggregated) product price for a specific bundle of characteristics and amenities at a specific time in a specific location.

Some of those economically (or otherwise) dependent on inner-city bus service, for example, often pay what seem to be very high rents for very modest, even substandard or dilapidated, housing in proximity to bus lines and stops (Glaeser, Kahn, & Rappaport, 2008). A hedonic price model of such housing would likely reveal very high marginal willingness to pay for proximity to transit, controlling for other housing characteristics. Although the high relative value of proximity to transit may be reflected in apparently high rents for people of modest means, relative to housing of similar character and quality not well served by transit, these rents often fail to induce new development or value creation. On the contrary, in many cases, given absolute income constraints, high rents for poor properties may work to keep those properties in place and in service long after the point where they might otherwise be desirable. It is conceivable that where consumers' willingness to pay premium prices for proximity to transit in excellent market locations may lead to new development, redevelopment, value creations, and concerns such as gentrification, similar willingness to pay for proximity to transit in weak market locations make result in substandard properties remaining in service and contributing to blight.

Particularly in environments close to newly developed transit stations where land, development, and construction costs are likely to be elevated, affordability will often be an issue. Where consumers' incomes or willingness to pay in the aggregate are insufficient to overcome high real estate prices, sites surrounding stations are likely to remain underdeveloped or fallow altogether. We observe many anecdotal examples of this, and this seems to be reflected in the data.

For purposes of calculating historical value creation or estimating prospective value creation in response to new transit investment, the hedonic price model may embody systematic selection bias. Where transit lines include alignments through areas that are undeveloped, abandoned (as may be the case with previously industrial urban areas), or have otherwise suffered disinvestment, hedonic price models may imply an overstatement of the value creation potential of market response to new infrastructure investment, or model results may be misinterpreted in this way. Hedonic price models do not disaggregate and estimate relative values of characteristics or amenities, say proximity to transit stations, of office, retail, or residential buildings that go unbuilt. Hedonic price analyses of buildings proximate to transit stations evaluate only those which are or were economically and financially viable. They do not analyze buildings that go unbuilt because they are or would be dis-economic. To measure value creation in the aggregate we must capture changes in value of assets where value creation was modest or negative as well as those which benefitted significantly from new infrastructure investment as a result of accommodative market conditions. It is possible that new transit infrastructure investment (and, perhaps, the land speculation and regulation that often accompany it) may indirectly impede private sector value creation in some locations while spurring it in others.

Bus rapid transit (BRT) and other value impact studies

Value impact studies have been undertaken with respect to a wide range of public infrastructure investments. Within the sphere of transportation infrastructure alone, such studies have evaluated impacts of dredging and port projects, new arterial or highway bridges, airport development, toll roads, freeway interchanges, and heavy and commuter rail in addition to light rail transit improvements. A subset of this literature, closely related to that which studies the value impacts of light rail transit, is literature estimating value creation and/or other impacts associated with bus rapid transit (BRT).

Extensive study has been undertaken with respect to Bogota's TransMilenio, considered by many to be the most state-of-the-art BRT system in the world. TransMilenio is an extensive system operating 125 stations (of iconic design) along eleven corridors and 112.9 km. Recent studies have included land use impacts (Rodriguez, Vergel-Tovar, & Camargo, 2016); value premiums as a function of walking distance (time) from stations (Munoz-Raskin, 2010; Rodríguez & Targa, 2004); capitalization of BRT network expansions effects (Rodríguez & Mojica, 2009); land value impacts of BRT (Rodriguez & Mojica, 2008); planning for development in accommodation of BRT (Gakenheimer, Rodríguez, & Vergel, 2011); the relationship between urban form and station boardings (Estupiñán & Rodriguez, 2008); examination of the reciprocal relationship between BRT and the built environment in Latin America (Vergel-Tovar, 2016); and public transport investments and urban economic development (Heres, Jack, & Salon, 2014).

Other BRT studies examining development patterns (Cervero & Landis, 1997; Fogarty & Austin, 2011); inducement of TOD, or as prospectively cost-effective alternatives to LRT include: planning for BRT as a modal alternative to "Light Rail Lite" (Hoffman, 2008); leveraging TOD with BRT investment (Cervero & Dai, 2014); BRT and urban development (Rodriguez & Vergel, 2013); BRT as a substitute for LRT (Sislak, 2000); comparison of BRT and LRT fixed guideway systems (Biehler, 1989); a review of BRT literature (Deng & Nelson, 2011); real estate impacts from fixed rail and BRT (Kannan, 2011); and impact of bus transit centers on values of nearby single-family residential land in Houston, Texas (Lewis & Goodwin, 2012).

Light rail transit and transit-oriented development (LRT and TOD)

Transit-oriented development (TOD) is one specific type of the many potential forms of transit-influenced development. TOD is typically composed of vibrant mixed-use development that is amenity-rich and features proximity to transit. Many multimodal features are included in TOD, including pedestrian and bicycle improvements. Numerous studies have demonstrated that under certain circumstances, TOD can command higher sales prices and rents for a variety of property types. The opportunity for value creation and subsequent value capture will vary by transportation network and station characteristics. Unique characteristics of each transit line and station area will influence the potential for value creation and capture (Song, 2002).

This study addresses value creation in proximity to LRT stations without explicit distinction between TOD, other forms of transit-influenced development, or station areas in which there has been little discernable transit-induced value creation at all. TOD, the value it can create, and the price premiums it can command, have garnered a great deal of attention and inspired a great deal of academic and commercial study. Although this study does not focus on TOD per se, the subject commands some acknowledgment. In many cases, some significant part of that value capitalized into real estate prices in proximity to transit stations may derive as much or more from TOD or TOD-like urban amenities as from transit accessibility itself (Song & Knaap, 2003).

TOD involves:

> creating attractive, memorable, human-scale environs with an accent on quality-of-life and civic spaces. Increasingly, projects built around up-and-coming transit nodes, like Dallas's Mockingbird Station, Portland's Pearl District, and Metropolitan Chicago's Arlington Heights, are targeted at individuals, households, and businesses seeking locations that are vibrant and interesting; these places usually have an assortment of restaurants, entertainment venues, art shops, cultural offerings, public plazas, and civic spaces" (Cervero, 2004).

The many lifestyle and urban amenity benefits that may be realized from within transit-influenced projects … result not only from transit access but also from particularly complex and compact mixed-use real estate development and occupancy. The complexity and intensity of TOD projects can create risk and discourage value-maximizing real estate development and private-sector investment. TOD often requires significant up-front investment in infrastructure and common amenities (Carlton, 2009). Many of the requirements for successful value creation within TOD fall outside the control of developers and require engagement, collaboration, and partnership with transit agencies and local governments (Hale, 2008; Hale & Charles, 2007; Hale, 2013). A great deal of cooperative engagement and strategic partnership is required in both planning and execution. A paradigm shift is needed "from current practice of small scope—ad hoc, technical solution driven—planning approach towards a new practice that considers a broad network scope—strategy driven—planning approach" (p. 1, Arts, Hanekamp, and Dijkstra, 2014). These considerations underpin the survey questions posed to transit agency officials in the present study regarding strategic engagement, value creation strategies, and transit agency goals and objectives.

Numerous studies have estimated the impact of TOD and/or specific elements of TOD on various classes of real property values. Examples include measuring the impact of suburban TODs on single-family home values (Mathur & Ferrell, 2013); development density (Litman, 2014); economic development impacts (Litman, 2010); and effects of pedestrian elements of TOD (Bartholomew & Ewing, 2011). In general, these studies have identified positive value creation or increased consumer marginal willingness to pay (price effects) related to TOD and many of its common attributes or constituent parts (Clifton, Ewing, Knaap, & Song, 2008).

Quantifying effects of proximity to light rail transit stations on assessed valuation

Many studies have utilized indicators for price/value other than assessed valuation. These have included residential or office rental rates, realtor listing prices, deed records, proprietary records of sample transactional data, repeat sales records, and market price indices, in addition to assessed value. Several papers have supported the validity of assessed valuation data as a measure of value and for purposes of developing price indices (Case & Wachter, 2005; Clapp & Giaccotto, 1992; Gatzlaff

& Holmes, 2013; Jud & Winkler, 1999).

Although assessed valuation data can suffer from several drawbacks as proxy for market value, they have advantage that they are available for all revenue acreage within subject treatment and control areas and are subject to consistent methodologies within, if not between, jurisdictions in this study. Assessed values are perhaps "the most comprehensive and reliable government data source for residential property values" (Hess & Almeida, 2007). Another significant advantage of assessed valuation data is that they incorporate the entire universe of (taxable) properties whereas other datasets based on real estate transactions reflect only those properties that have been traded in the marketplace.

Examples of studies that have employed assessed valuation data for similar purposes include: *The Impact of the Miami Metrorail on the Value of Residences near Station Locations*, 1990 Dade County property tax records (Gatzlaff & Smith, 1993) and Impact of Proximity to Light Rail Rapid Transit on Station-area Property Values in Buffalo, New York (Hess & Almeida, 2007). Other studies employing assessed valuation to estimate the effect of transit station proximity on property values include the following examples by market: Atlanta, Georgia (MARTA), DeKalb County tax assessor (Nelson, 1992); Dallas, Texas, (DART), Dallas County Central Appraisal District (Weinstein et al., 2002); Miami, Florida (Miami Metro Rail), Dade County property tax records (Gatzlaff & Smith, 1993); Philadelphia, Pennsylvania (SEPTA), Montgomery County tax assessor (Voith, 1993); and Portland, Oregon (Eastside MAX), City of Portland tax assessor (Lewis-Workman & Brod, 1997).

Assessed value is not without limitations as proxy for real-time market value and, therefore, as a metric for value creation in a true economic sense; this is addressed below under "Limitations." Assessed valuation may be the best and most appropriate measure of private sector real estate market value for purposes of public policy evaluation and public-sector infrastructure finance, however. Assessed valuation is the measure and methodology on which all U.S. state and local governments and political subdivisions rely for raising revenue through ad valorem taxation. In addition to, and aside from, enterprise funds such as those often associated with public water and wastewater treatment or solid waste systems, general fund revenues, and the taxable assessed value on which they explicitly depend, are those on which local and many state governments literally bank. Assessed value is the measure of (taxable private sector) real property value on which policy makers and public-sector financiers depend and with which they are familiar. Assessed value is the lingua franca of municipal and ad valorem tax revenue-based finance.

Many (real estate value dependent) public-sector infrastructure finance strategies and mechanisms depend explicitly on assessed valuation. These include general fund obligations, special ad valorem tax districts, tax increment financing (TIF), land value taxation, and so on. Even special assessments not levied explicitly against assessed value (or any other measure of value per se) are calibrated based on the relative assessed values of various classes of real estate.

An additional advantage of assessed value as a measure of market response over time is the comprehensive nature of the available data. The database(s) analyzed in this study comprised approximately 17 million folio (tax property) records within treatment and control groups, as opposed to the hundreds or thousands typically available in repeat sales or alternative databases at similar geographic scale. Values are reflected for every tax parcel (folio) within treatment and control areas as opposed to only those which have changed hands or about which transaction data have been reported voluntarily. Additionally, assessed valuation records include folios (and accompanying valuations) for every type of taxable real property including vacant land, office, retail, institutional, industrial or other commercial buildings, as well as single-family, multi-family, owner-occupied and rental residential real estate.

Accounting for the value of every parcel of property in every class of (taxable) real property provides for a more comprehensive and unbiased measure of aggregate value over time (i.e. the quantity of interest) than observing only those properties of a specified class that have been subject to repeat sales.

Consideration of station-specific characteristics and transit agency initiatives, and variation in differential rates of LRT-influenced value

Station-specific characteristics may matter with respect to value creation because they may affect the way commuters and other interact with the station and surrounding built environment, beyond merely accessing transit cars. A 2007 study of 14 U.S. rail systems by Matthew Kahn found that stations defined as walk-and-ride (WAR, no parking provided) generated a 3 percent premium in house prices, whereas stations defined as park-and-ride (PAR, parking provided) generated no residential price premium (Kahn, 2007).

A 2011 study of TOD of the San Diego, CA, condominium market found that "station proximity has a significantly stronger impact when coupled with a pedestrian-oriented environment. Conversely, station area condominiums in more auto-oriented environments may sell at a discount. This indicates that TOD has a synergistic value greater than the sum of its parts" (Duncan, 2010). Other studies have found similarly positive relationships between high-quality pedestrian environments and real estate values (Li & Hsieh, 2014; Li & Lai, 2009).

An early study of Orenco Station in Hillsboro, Oregon found that most [of its] residents appear to have chosen the community because of its upscale character, design characteristics and open space rather than because of its transit access (Bae, 2002). The implication was that high-quality pedestrian environments may contribute as much or more to value creation (or price premium) as proximate transit access. Other research has found that high-quality "new urbanist" development can command price premiums independent of transit access (Eppli & Tu, 1999; Song & Knaap, 2003, 2006).

Timing of value impacts

Many studies conceptualize treatment as transit service delivered through stations in fixed locations from the date of commencement of service. Prospectively value-inducing treatment, comprised of new station development in fixed locations, however, does not occur at a discrete moment in time. Some of this literature demonstrates or observes that proximity to LRT stations positively affects property values prior to development and commencement of operation of those stations.

A 2012 study showed that "completing environmental review adds … value, as does breaking ground for construction, as does the opening of the system" and that "there can be increments of value accretion as a project is seen through its various planning stages, and that different property markets respond differently" (Golub et al., 2012). Planning transit development projects "in the sunshine" creates material challenges for those with an interest in maximizing value creation and value capture on behalf of public sector investors in transit (Kaza & Hopkins, 2009).

Economist Henry George theorized that real estate market volitility is increased by land speculation (Bryson, 2011; George, 1879). Recent studies have suggested that particularly in the absence of land value taxation, such (pre-transit development) speculation may distort value creation and complicate effort to capture value for public investment (Gihring & Nelson, 2005; Gurdgiev, 2012a, 2012b). Katherine Kittrell (2012) finds that pre-transit development land speculation subsequent to project announcement can "create sharp initial property premium increases" (p. 143). Once such price premiums level off, they may not materialize again until market conditions allow for "significant new public and private investment in accessibility or quality walkable, mixed-use development" (p. 143). In addition, she finds that land speculation and assemblage may deter TOD particularly where buildings are demolished and land remains vacant (Kittrell, 2012).

Such research prompts emphasis on significant and early strategic partnership between transit agencies and other public and private actors. Public sector investors must engage the market early, directly or indirectly, if they hope to maximize value creation and any resulting opportunity for value capture. "The earlier [public sector investors] get into the market, the more valuation increases they can capture for their public investments for land, transportation, affordable housing, or other developments" (Golub et al., 2012). Although there may be economic and strategic advantages associated with waiting to finalize plans and development strategies in some circumstances (Donaghy & Kaza, 2006), waiting to engage property markets and/or to implement value capture strategies until after transit development plans are finalized and announced may not be one of them.

Contribution(s) of this work

This study addresses shortcomings of previous work in several respects relevant to policy makers, planners, and financiers. This analysis estimates differential rates of value creation based on actual historical assessed valuation, rather than on economic (hedonic) modeling of inferred consumer willingness to pay for specific amenities. This study spans 11-years of value change as opposed to being cross-sectional or of much shorter duration. Many hedonic price models are cross-sectional in nature or consider very few time periods (often two). This study encompasses every tax folio (taxable real property) within study and comparison (i.e. treatment and control) areas surrounding stations, regardless of the extent of realized development in those areas. This study employs assessed value data, which is itself the basis for many value capture and financing mechanisms, as opposed to selective repeat sales or other data subject to interpretation and extrapolation. This study quantifies previous anecdotal observation that even where value creation responses have been robust in some areas (or near some stations) they have been very modest elsewhere or overall. This study also considers institutional characteristics of individual transit agencies, and the timing of value creation - both in response to comments and suggestions of other writers.

This analysis differs from many previous studies of the subject in that it encompasses a longitudinal analysis of value change over the 10-year period from 2005 through 2015. This study does not estimate value creation through a hedonic price model, but rather through calculated differences in actual assessed values over the period. This study captures values comprehensively for every taxable folio within areas of study or comparison, rather than selecting units of analysis from repeat sales or other less-than-comprehensive datasets. In addition to these differences, this study compares elements of (transit agency) institutional characteristics, perspectives, and strategies with respect to differential rates of aggregate value creation. This analysis also attempts to cast further light on the timing of differential value creation.

CHAPTER 3: RESEARCH METHODS AND DESIGN

This analysis employs mixed model analysis of variance (ANOVA) and panel regression to estimate the differential effect of treatment (proximity to light rail transit stations) on a treatment group (Transit Areas of Influence) compared to those within a control group, mimicking an experimental design. Specifically, this study estimates the average change over time in the outcome variable (various measures of assessed value) for the treatment group, compared to the average change over time for the control group.

Conceptual Framework

Transit-oriented, and much otherwise transit-influenced, development comprises bundles of complex and heterogeneous goods and services. The extent of value creation within transit areas of influence, and the opportunity for effective value capture, is dependent on economic, metropolitan and submarket conditions, as well as individual TOD-specific area-level attributes. These attributes include accessibility to transit, the character, quality, typology, and functional design of each development area and other factors. As consumer goods, TOD-specific real estate products and TODs themselves, as well as other TIDs, are valued (i.e. priced in the marketplace) based on the utility that can be derived from each of the attributes that define them (Lancaster, 1966). The value of one unit of real estate or parcel of land will vary from others based on the quantities of the various attributes reflected in that parcel and the relative value of those attributes to consumers (Tiebout, 1956).

The underlying land-rent theory is derived from neoclassical economic theories of non-farm housing production (Alonso, 1964; Muth, 1958). This theoretical framework is useful in describing the relationship between accessibility (and/or other amenities/attributes) and land values. It is assumed that households will trade off various real property attributes (including land area) for accessibility to transit. Proximate access to a LRT station is expected to provide market advantages to real property compared with properties not similarly served by transit. Proximate access to LRT stations is a scare resource in that the number of stations is finite, as is the acreage proximate to those stations. Households valuing proximity to transit (and/or related amenities) should be willing to pay a price premium for properties within TOD compared to similar properties in similar locations in the same timeframe, but more distantly located from transit stations. Such consumer preferences become capitalized into real property values within proximity to stations (Al-Mosaind et al., 1993; Cervero & Duncan, 2002c).

Conversely, some aspects of transit systems, including proximity to rail transit maintenance yards, elevated facilities, rights-of-way outside TAIs, or large surface or structured parking structures within park-and-ride facilities, may result in adverse impacts which also become capitalized into real property values. "Without attention to design, LRT stations may impose negative externalities on nearby properties, with a resulting decline in … values" (Al-Mosaind et al., 1993).

Methodology

This study first employs a mixed ANOVA methodology to estimate the extent to which station-specific transit agency policies and demographic characteristics are associated with differential ("treatment" vs. "control") rates of assessed value creation in the context of a longitudinal difference-in-differences analysis. Originally contemplated as a difference-in-differences regression model, various issues including missing data, commencement of service dates outside the period of available assessed valuation data, and desire not to further reduce the number of LRT stations under consideration, lead to identification of mixed ANOVA as the appropriate statistical methodology.

Following the ANOVA analysis, panel regression is performed on data from 200 stations subject to an alternative definition of treatment area to determine the extent to which various prospectively explanatory (generally time invariant) variables might explain variation in differential rates of total assessed value creation per acre over time.

The unit of observation was individual (station-specific) transit areas of influence (TAIs) defined as those areas (approximately 500-acres) within ½ mile radii of LRT stations. Changes in total assessed value across individual folios within 229 LRT station TAIs along 21 transit lines within 14 U.S. transit systems are considered within the ANOVA analysis. Total assessed value per acre within 200 of these stations (for which there were no missing annual data) was considered for the panel regression analysis. Note that several of the subject transit systems include stations on more than one LRT line. In addition to total assessed value, differencing was undertaken for tax folio density (count per acre), assessed valuation of land, and assessed valuation of improvements. Specific transit stations were selected based on timeframe relevant commencement of (line/station) service dates due to the availability of commercially available assessed valuation data from CoreLogic, extending from 2005 through 2015.

ArcGIS geographic information systems (GIS) software was employed to define geographic limits of treatment and control areas, and to identify tax folios located within those areas. Control geographies were defined as areas lying between 1-mile and 2-miles from subject stations, but excluding areas within ½-mile of rail lines themselves and areas within 1-mile of other (non-subject) stations. Assessed values of land, assessed values of improvements, and total assessed values are observed for more than 2-million folio records within treatment areas and more than 15-million folios within control areas over the 11-year period of observation. Estimation of differential rates of change in value over time, between treatment and control (as opposed to variation in assessed valuation in absolute dollar terms) allow analysis both locally at each station-specific TAI (the unit of observation) and across stations, lines, and systems.

Mixed model ANOVA

Five mixed (one-within, one-between) analyses of variance (ANOVA) models are employed; one each with respect to total assessed value, assessed land value, assessed improvement(s), and folio density. The mixed (one-within, one-between) ANOVA method is appropriate when assessing whether there are group differences on a continuous dependent variable measured over time (as is the case in this study). The within effect represents time and the between effect represents any group-wise differences, such as those based on treatment versus control (Tabachnick & Fidell, 2013). These within and between effects are considered “main” effects. Interaction terms will be evaluated to find the difference-in-differences (attributable to station-specific and policy characteristics) over time and differentiated between treatment (station proximity) and control. Demographic characteristics are included as covariates.

The underlying mixed ANOVA models are mathematically equivalent to the difference-in-differences regression, both employing the F-test to test the overall hypothesis (Tabachnick & Fidell, 2013). The null hypothesis in ANOVA is that the effect is not significantly different across (covariate) categories. “A mixed ANOVA compares the mean differences between groups that have been split on two "factors" (independent variables), where one variable is a "within-subjects" factor and the other is a "between-subjects" factor” ("Mixed ANOVA using SPSS Statistics,") Mixed-design analysis of variance is used to test for differences between two or more independent groups over repeated measures of individual subjects (Field, 2009). “The ANOVA model is a special case of regression in which all the predictors are categorical” (Yuan & Lin, 2006). There is no mathematical difference between ANOVA and regression. ANOVA allows one to assess the effect of a set of predictors (in this case) on the residuals. It estimates how much of the variance in the data can be explained by the dependent variables.

Following mathematical differencing between values within areas of treatment and control over time, mixed model ANOVA was used to estimate the significance and magnitude of the treatment effect controlling only for transit system (market/location) and various demographic covariates at the census block-level. One mixed ANOVA model was employed to estimate the significance and magnitude of the aggregate treatment effect over time controlling only for transit system (market/location) and various demographic covariates. Thereafter, four mixed ANOVA models were developed to estimate the significance of treatment (proximity to transit stations) over time, and to quantify the magnitude of any significant treatment effect controlling for an array of station-specific characteristics, and transit agency goals, objectives, and strategies. Models were developed for dependent variables (all expressed in per-acre terms) comprised of 1) total assessed value, 2) assessed value-land, 3) assessed value-improvements, and 4) folio density. Each model included repeated measures of value(s) over the 11-year time period and observations within treatment and control (areas).

Mixed ANOVA analyses estimated 1) overall between-subjects effect of treatment (i.e. proximity to station, differentiating treatment and control groups); 2) overall within-subjects effect of time (i.e. change in differential rates of assessed value change/creation from year to year during the 2005-2015-time period, regardless of proximity to station), and most importantly; 3) any significant interaction between time and treatment., which examines the extent to which there are significant differences in rates of change over time (in assessed value or folio density) between treatment and control areas.

Prior to the analysis, requisite assumptions of repeated measures ANOVA (identified above under "Research Methods and Design") were assessed and addressed. Normality was assessed through a Kolmogorov-Smirnov (KS) test. The KS test was significant (i.e., $p < .05$) for most of the dependent variables within both treatment and control groups, indicating that normality could not be assumed. Where sample sizes are large however ($N > 50$), as in this dataset, ANOVA is robust with respect to violations of the normality assumption. In such conditions, ANOVA may be continued as proposed (Howell, 2016; Pallant, 2013; Pituch & Stevens, 2015; Stevens, 2012; Tabachnick & Fidell, 1936; Tabachnick & Fidell, 2007; Tabachnick, Fidell, & Osterlind, 2001).

Sphericity was examined using Mauchly's test. None of the variables exhibited sphericity ($p < .001$ in all cases), thus violating a requisite ANOVA assumption. To compensate, the Greenhouse-Geisser correction, which adjusts the test statistic for violations of sphericity, was applied to interpret all analytical results.

Homogeneity of variance and covariance matrices were assessed next. Homogeneity of variance was assessed using Levene's test, and was met for some variables ($p > .05$), but not met for others ($p < .05$). Homogeneity of covariance was assessed using Box's M test. Box's M test could not be calculated due to the large number of variables in the model. Because homogeneity of covariance could not be assessed, the more conservative Wilk's lambda coefficient was interpreted to compensate for any possible violation of the homogeneity assumptions. Wilk's lambda is a more conservative statistic in that it is less likely to indicate significance, but is also less susceptible to the possibility of Type I error (i.e. the incorrect rejection of a true null hypothesis) introduced by the violations of homogeneity (Stevens, 2016).

Treatment (i.e. an indicator variable denoting treatment or control group) was the principal independent variable in each of the five models. Covariates included a transit system (location) identifier and a variety of demographic characteristics (selected as described above) including: median household income, per capita income, gross rent burden greater than 30%, persons per household, percent dwellings vacant, percent dwellings owner occupied, total vehicles per household, total vehicles per owner-occupied household, and total vehicles per renter-occupied household. Except for the first model, covariates included those identifying station-specific characteristics such as station typology, character, design, and number of transit agency provided parking spaces. [Station design was dichotomized due to small group frequencies, resulting in a variable with two levels consisting of *at grade* and *other*]. Additional covariates addressed transit agency design and development objectives (e.g. reducing roadway congestion), employment of value creation strategies (e.g. land use, zoning, and entitlement enticements), and employment of specific value capture strategies.

Tables 1a and 1b identify variables of interest as well as covariates—including those identifying station location, station-specific characteristics, transit agency perspectives and initiatives, and as demographic characteristics at the census block-level.

Table 1: Variables, measures, and sources

Variable	Measure	Source
Geographic Location		
Transit System	Metro area	American Public Transportation Association
FIPS Code		U.S. Census Bureau
Transit Line	Name	Individual transit agencies
Station Location (centrioid latitude and longitude)	Coordinates	American Public Transportation Association
Assessed Valuation		
Tax folio counts	Count	CoreLogic
Assessed Value – Land	Dollars	CoreLogic
Assessed Value – Improvements	Dollars	CoreLogic
Assessed Value – Total	Dollars	CoreLogic
Station characteristics		
Commencement of service date (year)		Transit agency survey (Appendix I, V)
Station design type	Elevated	Transit agency survey (Appendix I, V)
	At grade	Transit agency survey (Appendix I, V)
	Open cut	Transit agency survey (Appendix I, V)
	Underground	Transit agency survey (Appendix I, V)
	Other	Transit agency survey (Appendix I, V)
Station typology	Downtown – CBD	Transit agency survey (Appendix I, V)
	Urban center	Transit agency survey (Appendix I, V)
	Urban neighborhood	Transit agency survey (Appendix I, V)
	Suburban town center	Transit agency survey (Appendix I, V)
	Suburban neighborhood	Transit agency survey (Appendix I, V)
	Campus, entertainment, special	Transit agency survey (Appendix I, V)
	Other	Transit agency survey (Appendix I, V)
Dominant station character	Walk-and-ride	Transit agency survey (Appendix I, V)
	Park-and-ride	Transit agency survey (Appendix I, V)
	Other	Transit agency survey (Appendix I, V)
Parking spaces (number) provided at station	Count	Transit agency survey (Appendix I, V)
Primary goals or objectives …	Serving existing commuters	Transit agency survey (Appendix I, V)
	Serving anticipated residents and workers	Transit agency survey (Appendix I, V)
	Inducing transit ridership	Transit agency survey (Appendix I, V)
	Relieving roadway congestion	Transit agency survey (Appendix I, V)
	Economic development	Transit agency survey (Appendix I, V)
	Growth management, environmental, other public policy	Transit agency survey (Appendix I, V)
	Political or public initiatives or agenda	Transit agency survey (Appendix I, V)
	Initiatives of commercial interests or private developers	Transit agency survey (Appendix I, V)
Transit agency value creation strategies	None: no specific value creation strategy	Transit agency survey (Appendix I, V)
	Strategic public/private partnership	Transit agency survey (Appendix I, V)
	Land use, zoning, entitlements	Transit agency survey (Appendix I, V)
	Complementary infrastructure investment	Transit agency survey (Appendix I, V)
	Land assemblage, acquisition, or other real estate	Transit agency survey (Appendix I, V)
	Other	Transit agency survey (Appendix I, V)

Table 1b: Variables, measures, and sources continued

Variable	Measure	Source
Station characteristics - continued		
Year substantive public-private partnership commenced	Year	Transit agency survey (Appendix I, V)
Specific value capture mechanisms were employed	Joint Development	Transit agency survey (Appendix I, V)
	Negotiated Exactions	Transit agency survey (Appendix I, V)
	Tax Increment Financing (TIF)	Transit agency survey (Appendix I, V)
	Special Assessments	Transit agency survey (Appendix I, V)
	Impact Fees	Transit agency survey (Appendix I, V)
	Land Value Taxation	Transit agency survey (Appendix I, V)
	Naming Rights	Transit agency survey (Appendix I, V)
	Other	Transit agency survey (Appendix I, V)
	None	Transit agency survey (Appendix I, V)
Timeframe in which value capture strategies initiated	Year	Transit agency survey (Appendix I, V)
Significance or importance of value capture strategy…	Very Important	Transit agency survey (Appendix I, V)
	Significantly Important	Transit agency survey (Appendix I, V)
	Moderately Important	Transit agency survey (Appendix I, V)
	Somewhat Important	Transit agency survey (Appendix I, V)
	Slightly Important	Transit agency survey (Appendix I, V)
	Not Important	Transit agency survey (Appendix I, V)
Importance of public-private value creation strategies	Very Important	Transit agency survey (Appendix I, V)
	Significantly Important	Transit agency survey (Appendix I, V)
	Moderately Important	Transit agency survey (Appendix I, V)
	Somewhat Important	Transit agency survey (Appendix I, V)
	Slightly Important	Transit agency survey (Appendix I, V)
	Not Important	Transit agency survey (Appendix I, V)
Importance value capture	Very Important	Transit agency survey (Appendix I, V)
	Significantly Important	Transit agency survey (Appendix I, V)
	Moderately Important	Transit agency survey (Appendix I, V)
	Somewhat Important	Transit agency survey (Appendix I, V)
	Slightly Important	Transit agency survey (Appendix I, V)
	Not Important	Transit agency survey (Appendix I, V)
Open ended questions:	Has the importance of value capture changed over time?	Transit agency survey (Appendix I, V)
	The greatest barriers to realizing value capture?	Transit agency survey (Appendix I, V)
	Lessons learned re: value creation and value capture…	Transit agency survey (Appendix I, V)
	Suggestions or recommendations…	Transit agency survey (Appendix I, V)
Demographic characteristics		
SEX BY AGE		U.S. Census Bureau (Appendix IV)
MEDIAN AGE BY SEX		U.S. Census Bureau (Appendix IV)
EDUCATIONAL ATTAINMENT FOR THE POPULATION 25 YEARS AND OVER		U.S. Census Bureau (Appendix IV)
MEDIAN HOUSEHOLD INCOME IN THE PAST 12 MONTHS		U.S. Census Bureau (Appendix IV)
PER CAPITA INCOME IN THE PAST 12 MONTHS		U.S. Census Bureau (Appendix IV)
EMPLOYMENT STATUS FOR THE POPULATION 16 YEARS AND OVER		U.S. Census Bureau (Appendix IV)
OCCUPANCY STATUS		U.S. Census Bureau (Appendix IV)
TENURE		U.S. Census Bureau (Appendix IV)
POPULATION IN OCCUPIED HOUSING UNITS		U.S. Census Bureau (Appendix IV)
AVERAGE HOUSEHOLD SIZE OF OCCUPIED HOUSING UNITS		U.S. Census Bureau (Appendix IV)
TENURE BY VEHICLES AVAILABLE		U.S. Census Bureau (Appendix IV)
AGGREGATE NUMBER OF VEHICLES AVAILABLE BY TENURE		U.S. Census Bureau (Appendix IV)
GROSS RENT AS A PERCENTAGE OF HOUSEHOLD INCOME		U.S. Census Bureau (Appendix IV)

Geographic Information Systems

Locations of the fourteen (14) U.S. LRT systems are considered in this analysis. Subject transit lines include Charlotte, CATS Blue Line; Dallas, DART Green Line; Denver, RTD Blue, Orange, and Purple Lines; Houston, MetroRail; New Jersey Transit, Hudson-Bergen and River Lines; Los Angeles Metro Expo and Gold Lines; Minneapolis, Metro Blue Line;

Norfolk, Tide Light Rail; Phoenix, Metro Light Rail; Portland, TriMet MAX Green, Red, and Yellow Lines; San Diego, Oceanside Sprinter; Seattle, Link Light Rail; and Salt Lake City, TRAX Red Line, Redd Line-Airport, and Green Line. These are depicted in Figure 5 below.[2]

Figure 5: 14 U.S. transit systems comprising the subjects of this analysis

Treatment Areas

Selection of treatment areas surrounding the 229-subject LRT station areas was based on the primary transit ridership catchment areas within TAIs as defined by the American Public

[2] The St. Louis MetroLink light rail system, with lines and station in both Illinois and Missouri was dropped from the analysis due to extensive missing data and other data problems.

Transportation Association (APTA). APTA defines TAIs as those "spatial areas in which transit stops and stations typically have the greatest impact on land use and development and from which there is high potential to generate transit ridership" APTA further delineates TAIs "for purposes of influencing decisions about private and public investments and services." Primary catchment areas, defined as those contained within ½-mile radii from station centers (and including the "transit core"), are those:

> within which land use and urban design features, as well as the ease and directness of access to the stop or station, have a substantial impact on transit ridership and pedestrian access. The primary catchment area may generate a significant portion of total transit trips to and from the stop or station. (APTA, 2009)

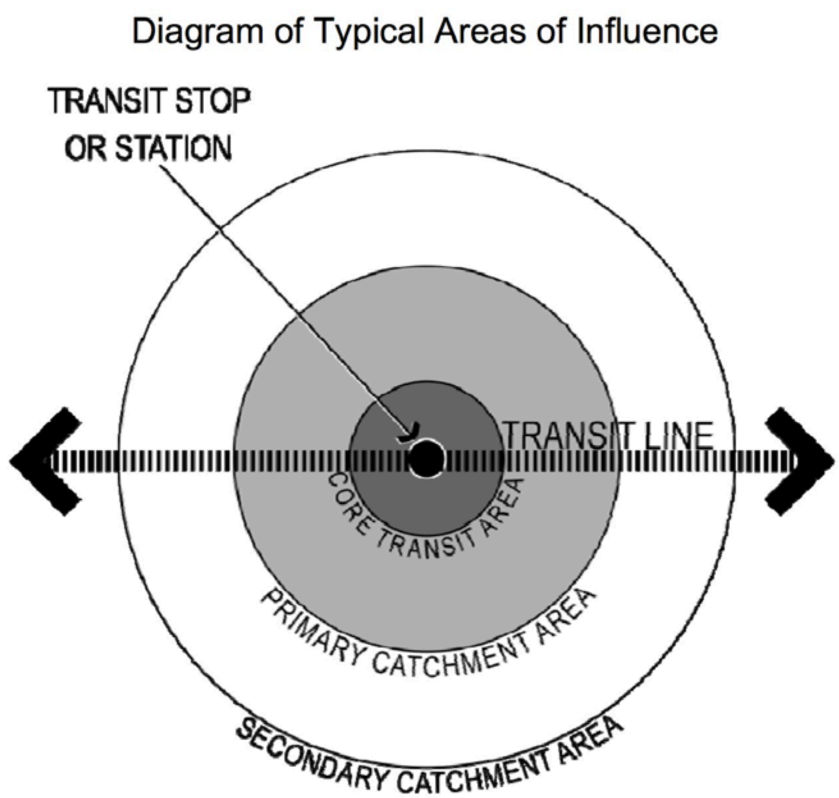


Figure 6: Defining Transit Areas of Influence APTA SUDS-UD-RP-001-09 (APTA, 2009)
Primary Catchment Area – Light Rail Transit: ½-mile Radius

Coordinates for latitude and longitude were collected for the centroids of each of the 229 subject stations. ArcGIS was employed to define individual treatment area geographies within a ½-mile radius of each station centroid. Within the ANOVA part of the analysis, and in cases where treatment areas overlap because station centroids are within 1-mile of each other, overlapping treatment areas were cropped employing a Thiessen polygon and GIS union method to eliminate overlapping areas and to avoid double counting of folio values within treatment areas. The concern here was that double (or triple) counting values within treatment areas (in the sense that the same folio could appear within ½ mile of two or more station centroids) might positively bias apparent rates of differential value creation.

Thiessen polygons were constructed, then a union function was run with the 1/2-mile buffers to create non-overlapping territories for each transit stop. Thiessen polygons are those with boundaries defining areas closest to each point relative to all other points. This method for defining treatment areas where there would otherwise have been overlap was used for three reasons: 1) GIS processing complexities required to bisect areas of overlap precisely within ½ mile transit stop buffers, 2) time intensiveness otherwise required to manually interpret and delineate boundaries, and 3) ease of replicating results for extended future research or study. A detailed description of this and other GIS procedures has been provided by Phillip McDaniel, GIS Librarian, and appears as Appendix III.

Figure 7 provides an illustrative example of discrete treatment area definition employing the Thiessen polygon and Union method.

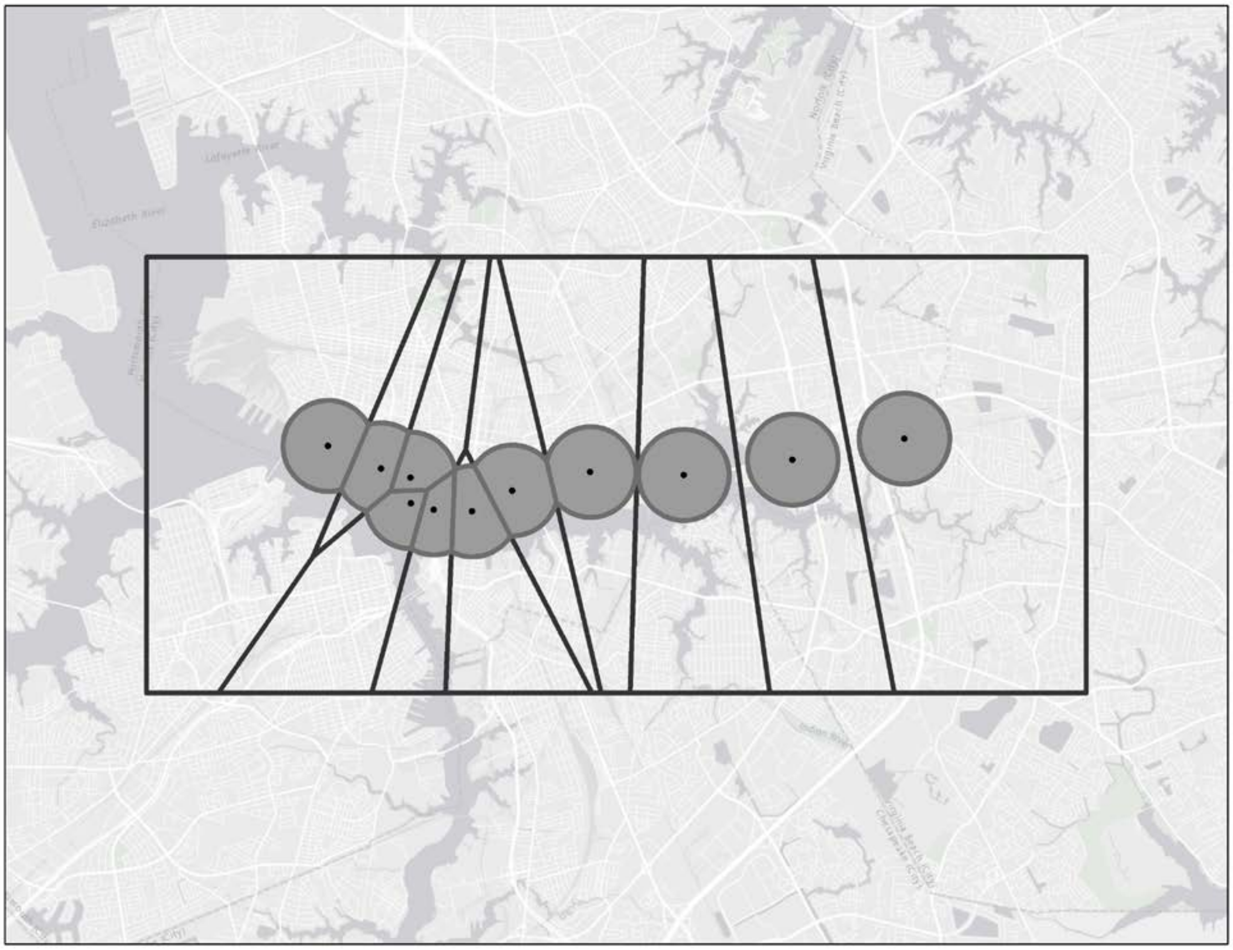


Figure 7: Treatment areas defined exclusive overlaps using Thiessen polygon and union method

Treatment areas not required to be cropped to eliminate overlapping with contiguous station areas comprise 502.66 acres within the ½-mile radius. The station area with the smallest geographic area, due to elimination of overlaps, comprises 137.60 acres (the Nicollet Mall station on the Blue Line in the Minneapolis Metro system). In total, the 229 treatment areas comprise 93,847.76 acres, or a mean of 409.82 acres per station area. Individual folio records are selected into treatment for all folios with a geographic centroid falling within the treatment area. All others are excluded.

Control Areas: Geographies surrounding subject TAIs

Control areas surrounding the 229-subject LRT station areas are defined as those within and bounded by 1-mile and 2-mile radii from the centroids of each of the 229-subject stations. Unlike treatment areas, no cropping of control areas is undertaken to eliminate overlapping control geographies. The size of specific control areas varies not because of contiguous control geographies, but because of the elimination of nearby treatment and other buffer areas from control.

To minimize the extent of treatment confounding control, and to minimize the extent to which particular folios (large land parcels in particular) might overlap treatment and control areas, treatment and control areas are separated by a ½-mile buffer as illustrated in Figures 9 and 10. In addition to the buffers surrounding treatment areas, a ½-mile buffer from the centerline of subject LRT lines is excluded from control areas. Rationale for elimination of folios within the ½-mile buffer area surrounding stations is that (notwithstanding APTA definition of primary catchment areas within TAIs), any treatment effect of proximity to transit stations including the benefits of mobility and accessibility being capitalized into real estate and reflected through market prices and assessed valuation, does not and would not end abruptly at the ½-mile radius. One practical effect of this, in the event that differential value creation effects are positive, is that comparing rates of change between control areas (at greater distance from stations) and those areas most impacted/benefited by proximity to stations is likely to overstate any aggregate treatment effect. On the other hand, this study is likely to underestimate aggregate differential value creation insofar as there is a positive (value-creating) treatment effect, it would likely extend beyond the arbitrary ½-mile radius. Conversely, where differential value creation effects of proximity to LRT stations may be negative, the effects would be reversed.

Rationale for elimination of folios within the ½-mile buffer along rail line corridors outside of TAIs is that proximity to LRT lines and rail traffic may have a negative effect on the value of property not proximate to stations (within treatment areas) (Armstrong & Rodriguez, 2006). Folios within these buffer areas are eliminated to avoid overstatement of any prospectively positive treatment affect. The following two figures illustrate an outlying control area (in two large parcels) surrounding a central treatment area (the circle at center) and other nearby treatment areas not associated with the identified control area. The distance between the treatment area(s) and the control area comprise exclusion areas.

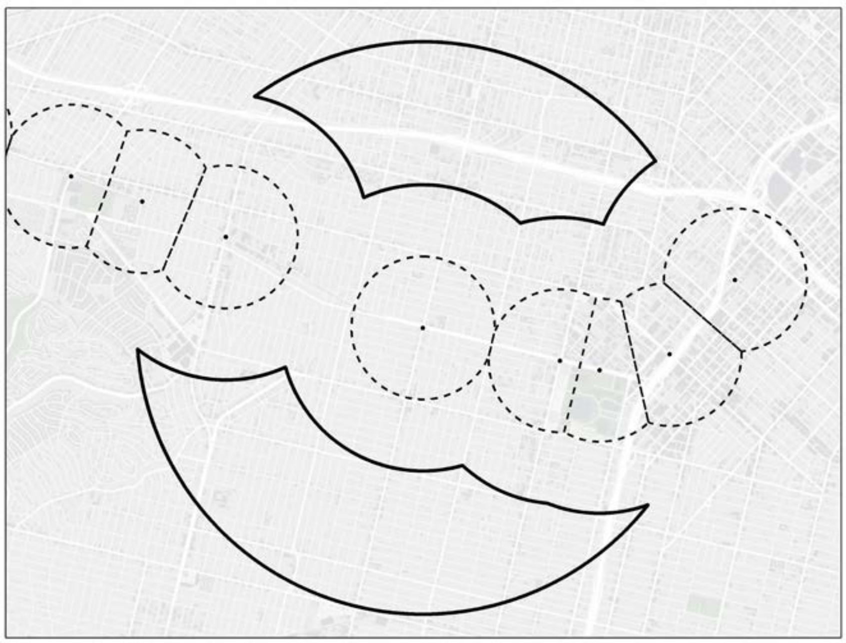


Figure 8: Representative treatment and corresponding control areas, exclusive of folio centroids.

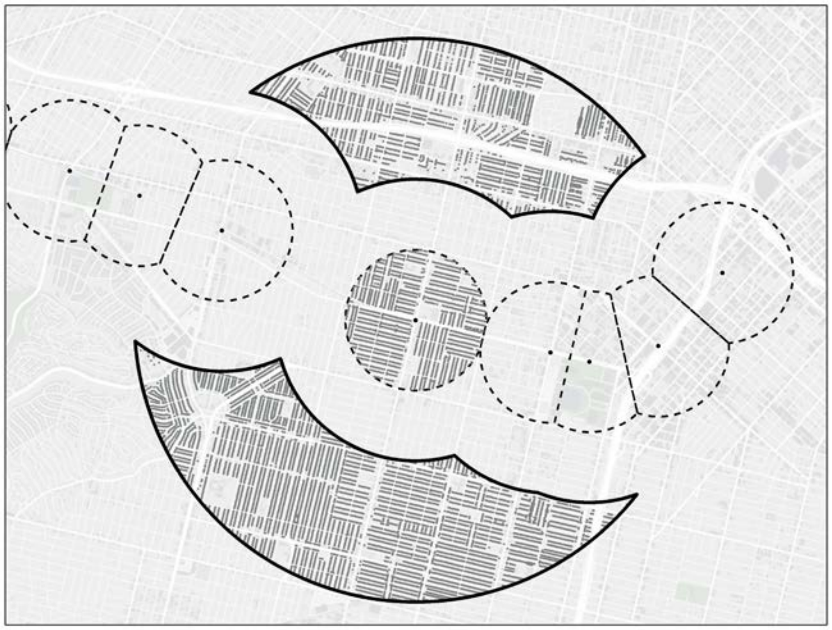


Figure 9: ***Representative treatment and corresponding control areas, inclusive of folio centroids.***

Control areas range in size from 1,937.73 acres (the Garfield Avenue station on the Hudson-Bergen line in the New Jersey Transit system) to 6,031.87 acres (the Bordentown and Florence stations on the River Line in the New Jersey Transit system, and the Tukwila International Blvd. station on Seattle's Link Light Rail system). In total (including overlapping control geographies), the 229 control areas comprise 826,526.07 acres, or a mean of 3,609.28 acres per station area. Individual folio records are selected into control for all folios with a geographic centroid falling within the control area. All others are excluded.

Quantifying effects of proximity to light rail transit stations on assessed valuation

This study employs a difference-in-differences approach to estimate differential rates of value creation within ½-mile of LRT transit stations (treatment), compared to those within areas between 1-mile and 2-miles from station centroids (control) over the 11-year period from 2005 through 2015. Year over year differences in assessed values within designated treatment areas are estimated on a percentage change basis and compared to those within control areas.

Differences between treatment and control areas are estimated for each of four values aggregated from the 2,080,619 individual (annual) folio records within treatment areas and 15,507,734 records within control areas. The four observed values include those for the assessed value of land (T_AVL for treatment and C_AVL for control), assessed value of improvements (T_AVI and C_AVI), total assessed value (T_AVT and C_AVT), and folio count (T_COUNT and C_COUNT). All values were converted to densities per acre based on the acreage of individual treatment and control areas.

Difference-in-differences is a quasi-experimental design that compares observed outcomes after treatment (commencement of transit service), and in some cases before treatment, within defined treatment areas (1/2-mile radius Primary Catchment Areas within TAIs), with control cases comprised of folios located at greater distance from stations. The DD design seeks to isolate the effect of treatment (the difference of interest) from any difference that would have resulted in the absence of treatment (Meyer, 1995). Kuminoff, Parmeter, and Pope have found "the difference-and-difference model with spatial dummies [to be] most accurate in identifying [marginal willingness to pay] in situations where there is a time dimension to the data…" (Kuminoff, Parmeter, & Pope, 2009).

The DD design can help address omitted variable bias, long a concern with respect to hedonic price models. We may expect (even desire) transit amenities to be correlated with unobserved neighborhood characteristics (or those which are difficult to capture with quantitative data). We can "use spatial fixed effects to help absorb the confounding influence of omitted variables and … quasi-experimental methods [such as DD] to purge time-constant omitted variables from [models]" (Kuminoff, Parmeter, & Pope, 2010).

Mixed model ANOVA

This study employs multiple mixed ANOVA models (one-within and one-between with covariates), where the within-subject factor is time (11 time periods for each dependent variable), and the between-subject factor is group (treatment or control) as categorical independent variable. The dependent variable in the principal model consisted of total assessed value per acre per year from 2005 through 2015. Additional models with dependent variables consisting of assessed value-land per acre, assessed value-improvements per acre, and folio density per acre are addressed in greater detail in the "Supplemental Studies" section below. Assessed value and folio densities are expressed in per acre terms to facilitate level comparison between treatment areas, and treatment and control areas, of significantly different sizes. The independent variable was treatment group (treatment or control), and covariates included those controlling for location, station and transit agency specific characteristics and various demographic characteristics.

The effect of group (treatment or control), and the interaction effect between time and group is used to test the hypothesis that assessed value of real property in proximity to light rail transit stations will increase faster over time than surrounding properties located at greater distance from stations. The interaction constitutes a difference-in-differences analysis (differences over time between differences between treatment and control).

The first mixed ANOVA model estimated the significance and effect size on values of the interaction between treatment and time controlling for location (by transit system), capturing local economic and market conditions, and demographic characteristics derived from 2010 American Community Survey data at the census block-level.

A statistically significant group effect indicates that there are significant differences between treatment and control within common time periods. Although calculation of such “main” effects is necessary within the mixed ANOVA model, these have little practical interpretive value in the context of this study.

The mixed ANOVA analysis can determine whether there is an overall between-subjects effect of treatment (proximity to station or treatment), whether there is an overall within-subjects effect of time (change in assessed value per acre from year to year during the period 2005 through 2015, regardless of proximity to station), and whether there is significant interaction between time and treatment. Evaluation of the time-treatment interaction will determine whether there is a significant difference in rates of assessed value creation between treatment and control areas over time. A statistically significant interaction between treatment and time indicates that the values within the treatment group were significantly different than those within the control group over time as a result of the treatment interaction.

Prior to analysis, the seven assumptions required for valid results from repeated measures ANOVA were assessed and addressed ("Mixed ANOVA using SPSS Statistics," ; Tabachnick & Fidell, 2007; Tabachnick et al., 2001). These include:

1. Dependent variable must be continuous; as is the case for all four measures of assessed valuation.
2. Within-subjects factor or independent variable (time, in this case) should consist of at least two categorical, related groups or matched pairs (treatment and control groups).
3. Between-subjects factor or independent variable (treatment and control) should each consist of at least two categorical, independent groups.
4. No significant outliers in any group of your within-subjects factor or between-subjects factor. (Obvious outliers were culled during data cleaning process.)

5. Dependent variable should be approximately normally distributed for each combination of the groups of your two factors (within-subjects factor and between-subjects factor). Normality was assessed through a Kolmogorov-Smirnov (KS) test. The KS test was significant (i.e., $p < .001$ to $p = .005$) for each of the four dependent variables both for treatment and control groups, indicating that normality cannot be assumed. However, when sample sizes are large (i.e., $N > 50$), as in this dataset, the ANOVA is robust with respect to violation of the normality assumption, so that analysis may be undertaken with valid results (Howell, 2016; Pallant, 2013; Stevens, 2012; Tabachnick et al., 2001).
6. Homogeneity of variances for each combination of the groups of within-subjects factor and between-subjects factor. Homogeneity of variance was assessed using Levene's test, and was met for some variables ($p = .073$ to $p = .978$), but not met for others ($p = .010$ to $p = .019$). Homogeneity of covariance was assessed using Box's M test. Box's M test could not be calculated due to the number of independent variables in the model. Given that homogeneity of covariance could not be assessed, the more conservative coefficient (Wilk's lambda) was interpreted to compensate for any possible violation of the homogeneity assumption, and to address the violations indicated by Levene's test.
7. Sphericity, the variances of the differences between the related groups of the within-subject factor for all groups of the between-subjects factor must be equal. Sphericity was examined using Mauchly's test. None of the variables exhibited sphericity ($p < .001$ in all cases). To compensate, the Greenhouse-Geisser correction was used to interpret results of all analyses.

Time interaction effects

Interaction effects represent the combined effects of independent variables on the dependent variable. In this case, we are most interested in differential value creation over time. We are particularly interested, therefore, with the interaction of time (across the 11-years of the study) with other independent variables such as station characteristics. When an interaction effect is significant, the impact of one independent variable is dependent on another (time in this case). One of the powerful utilities of ANOVA is its ability to estimate and test such interaction effects.

Where we find statistically significant interaction effects, we cannot interpret main (independent) effects without considering the interaction. In such cases, the effects of independent variable are not themselves independent. A statistically significant interaction between one independent variable and another (such as time) suggests that the effect of one independent variable has been moderated or modified by the other.

Research questions and hypotheses

The primary question of this research is **"Have higher rates of assessed value creation over time resulted within proximity (i.e. primary catchment areas within transit areas of influence) compared to similar locations at greater distance from new light rail transit service and stations?"**

The hypothesis anticipating this study was that higher rates of aggregate value creation have resulted in proximity to transit stations, but that differential rates of value creation would be inconsistent and highly varied across stations.

Total assessed valuation per folio, and the aggregate of total assessed valuation across all folios, is the basis on which ad valorem taxes are levied and the most relevant metric reflecting real property value for many fiscal impact, finance, and public policy considerations. This analysis focuses principally on total assessed valuation for this reason. Additional questions are considered with respect to other aspects of assessed valuation including:

- Have higher rates of assessed **land** values resulted over time within proximity (primary catchment areas within TAIs) than in similar locations at greater distance from light new light rail transit service and stations?
- Have higher rates of assessed **improvement** values resulted over time within proximity (primary catchment areas within TAIs) than in similar locations at greater distance from light new light rail transit service and stations?
- How do differential rates of change in assessed values of land and improvements differ from each other? This question is relevant, in part, because theory suggests that mobility and accessibility benefits become capitalized into land values, not into buildings and other improvements.
- Have higher rates of folio (count/acre) creation over time resulted within proximity (primary catchment areas within TAIs) than in similar locations at greater distance from light new light rail transit service and stations?

Although we may conceptualize commencement of station operation (availability of transit services) as the temporal point of treatment for purposes of distinguishing longitudinal panel data pre-treatment and post-treatment, the effect of proximity to (existing or proposed) LRT stations on real property values does not occur at a single, discrete moment in time. Land and other real estate prices may reflect either positive or negative effects of such proximity years before a system is delivered and a station is opened for operation and service. Real estate markets respond to announcements of transit studies and alignments, determination of station locations, commencement of engineering, funding commitments, and commencement of construction.

> It does not necessarily follow that if land prices jump once a rail service begins that transit caused this appreciation. Spikes in land values could be attributable to other factors, like an upswing in the regional economy, improved highway conditions, or better schools. The challenge, then, is to control for such potential confounding factors so that the unique effects of transit proximity on land values can be partialed

out (Cervero & Duncan, 2001).

Panel Regression

Supplementing ANOVA, a second analysis was performed on the 200 of 229 station areas for which there were no missing annual assessed valuation data. Regression analysis was performed on panel data constructed based on a different research design premise, and definition of treatment area, than that underpinning the ANOVA analysis reported above. Each of the (502.66 acre) Transit Areas of Influence (treatment areas) within ½-mile of station area centroids was considered in its entirety, regardless of whether or not that treatment area encroached into and overlapped one or more adjoining Transit Areas of Influence. Whereas Thiessen polygons and a GIS union method were previously employed to eliminate overlapping treatment areas and to avoid double counting of folio values within treatment areas, no such "cropping" of treatment areas was undertaken for this alternative analysis; this revised definition of treatment areas includes every folio within ½-mile of station centroids.

Figure 10: Overlapping Transit Areas of Influence and Treatment Areas

Differential rates of total assessed value growth per acre, by station per year, were regressed on a variety of prospectively explanatory variables to estimate the extent to which they may cause differential rates of assessed value growth. Independent variables were comprised of transit system, station characteristics (design, typology, character), transit agency goals and objectives, value creation and value capture strategies, the relative importance to transit agencies of various objectives and outcomes, and a variety of demographic characteristics, all previously described. Given that many of the independent (prospectively explanatory) variables are time-invariant with respect to stations, random-effects panel regression was employed (A Kohler & A Kreuter, 2012). Practical experience, intuition, and results presented herein all suggest that differences across stations, lines, and transit systems (metropolitan markets) unaccounted for in these analyses, have influence on the rate of assessed value creation per acre.

CHAPTER 4: DATA

Previous studies evaluating assessed valuation data have relied on records from individual tax assessors' offices, or commercial data services such as Metroscan. Studies evaluating representative sales or repeat sales data also rely on commercial data providers such as TRW REDI, RLIS, Costar, First American Real Estate Solutions, and others. This study employs assessed valuation data provided by CoreLogic. Headquartered in Irvine, California, CoreLogic provides financial, real property, and consumer data and analytics to public sector, private sector, and academic clients. CoreLogic has been accumulating annual assessed valuation data within U.S. metropolitan jurisdictions for more than 30-years. As of the (2016) date of data procurement for this analysis, 2015 was the "current" year of data availability. (Unfortunately) CoreLogic maintains and makes available assessed valuation data only for the current years and ten (10) preceding years. Data for prior years is disposed of. Assessed valuation data available at the time of data acquisition was that for the period(s) 2005 through 2015. In addition to discontinuation of data maintenance for periods more than 10-years prior to current year, CoreLogic maintains the non-value elements of the assessed value folio records, such as building characteristics, etc., for the current year only.

Based on the 11-year period of data availability, individual U.S. transit lines and stations were selected for study based on relevant commencement of service dates. This selection resulted in 286 light rail transit stations eligible for analysis. Elimination of all stations along the St. Louis MetroLink line and various station along other lines for reasons of data availability and appropriateness reduced the total number of stations subject to analysis to 229 (see "Limitations" below, and a list of deleted stations in Appendix II).

Annual assessed valuation data by folio, geo-located by latitude and longitude per folio centroid, was acquired from CoreLogic for years 2005 through 2015 for those FIPS codes identified in Table 2.

Table 2: Transit systems and lines

Met Area	County	ST	FIPS	System	Line	Opened
Charlotte	Mecklenburg	NC	**37119**	CATS	Blue Line	2007
Dallas	Dallas	TX	**48113**	DART	Green Line	2009
Denver	Denver	CO	**08031**	Denver RTD	C Line - Orange Line	2002
	Arapahoe	CO	**08005**		E Line - Purple Line	2006
	Douglas	CO	**08035**		F Line - Red Line	2006
					H Line - Blue Line	2006
Houston	Harris	TX	**48201**	METRO Rail	METRO Rail	2004
Jersey City	Hudson	NJ	**34017**	Hudson–Bergen	Light Rail	2003
Los Angeles	Los Angeles	CA	**06037**	Metro Rail light rail	Gold Line To Pasadena	2003
					Gold Line Eastside Ext	2009
Minneapolis	Hennepin	MN	**27053**	METRO	Blue Line	2004
Norfolk	Norfolk (City)	VA	**51710**	Tide Light Rail	Tide Light Rail	2011
Oceanside	San Diego	CA	**06073**	SPRINTER	SPRINTER	2008
Phoenix	Maricopa	AZ	**04013**	METRO Light Rail	METRO Light Rail	2008
Portland	Multnomah	OR	**41051**	MAX Light Rail		2004
	Clackamas	OR	**41005**			2009
Salt Lake City	Salt Lake	UT	**49035**	TRAX	Red Line - Daybreak	2001
					Red Line SLC-IA	2011
Seattle	Pierce County	WA	**53053**	Link Light Rail	Tacoma Link	2003
	King County	WA	**53033**		Central Link	
St. Louis	St. Louis City	MO	**29510**	MetroLink	Red Line College	2001
	St. Louis	MO	**29189**		Red Line Shiloh-Scott	2001
	St. Clair	IL	**17163**		Blue Line Shrewsbury–Lansdowne	2006
Trenton	Mercer	NJ	**34021**	New Jersey Transit	River LINE	2004
	Burlington	NJ	**34005**			
	Camden	NJ	**34007**			

Selection of all FIPS code relevant folio records into treatment areas yields a total of 154,829 folio records in 2005 increasing to 207,677 in 2015. Similarly, selection of FIPS code folio data into control areas yields 1,198,661 folio records in 2005 increasing to 1,509,798 records in 2015. In total, 2,080,619 year-specific folio records are examined within treatment areas, and 15,507,734 records are examined within control areas. From each of these, values for assessed value of land (T_AVL for treatment and C_AVL for control), assessed value of improvements (T_AVI and C_AVI), and total assessed value (T_AVT and C_AVT) are extracted and aggregated at the station-level.

Differences in the following aggregated values (per acre) are calculated for each station-specific treatment area.

- Tax folio counts;
- Assessed Value – Land;
- Assessed Value – Improvements; and
- Assessed Value – Total

Values aggregated at the station-level are divided by acreage within each treatment and control area to provide like-kind comparison between treatment and control geographies of different geographic sizes. Treatment areas range from 137.60 to 502.66 acres with a mean size of 409.82 acres. Control areas range from 1,937.73 to 6,031.87 acres with a mean of 3,609.28 acres.

The primary metric of interest was differential annual rates of change in total assessed valuation over time between treatment and control. Rates of change are expressed in annual percentage terms, rather than changes in absolute dollar values, to facilitate comparisons between stations and transit lines across markets subject to very different price levels.

A description of census block-level demographic covariates derived from the American Community Survey data from 2010, and the methodology employed to select data for inclusion in models, follows in Appendix IV.

Selection of independent covariates for inclusion in model(s)

Covariate evaluation began with identification of potentially confounding variables (which variables produced a highly complex initial ANOVA model). Although inclusion of all available covariates would have allowed examination of each possible covariate's effect, it interfered with model execution as a practical matter. Early versions of the model were unable, for example, to calculate many of the two- and three-way interactions initially considered. Additionally, between-effects for several single variables could not be estimated. These included the transit agency goals and objectives as well as value creation and value capture strategies. Following removal of variables for which between-effects could not be estimated, the model was reconstructed excluding three-way (or greater) interactions.

The resulting, somewhat reduced, model was assessed to evaluate remaining variables for collinearity. Vehicles per renter household and vehicles per owner-occupied household were too highly correlated to be included together in the model. Vehicles per owner-occupied household had the stronger effect and was retained. Vehicles per renter household excluded. Other variables pre-assumed to be correlated were not problematic upon examination. These included parking spaces and station character and median household income and per capita income. In these cases, all variables were retained.

The final four models, controlling for station-specific characteristics and transit agency goals and objectives as well as transit system (location) and demographic characteristics, included 17 covariates, in addition to the effect of time and treatment.

Descriptive Statistics

The 229 transit stations studied were located along 21 light rail lines within 14 transit systems in 11 states. Of the 229 stations, 83.4% were developed at grade, 10.9% were elevated, 3.9% were open cut, and 1.7% were underground. The number of parking spaces provided by transit agencies at each station ranged from zero to 1,734, with a mean of 173.74 (*SD* = 292.75). A plurality of stations (38.9%) were located in urban neighborhoods; 20.1% were located in suburban neighborhoods; 14.8% were in Downtown-CBD areas; 9.2% served campus, entertainment, or special purpose districts; 7.9% were in suburban town centers; 7.4% were in urban centers; and 1.7% were located within some other locational designation.

Transit agency representatives characterized most stations (63.8%) as "park-and-ride" while 36.2% were characterized as "walk-and-ride." Transit agency goals and objectives in planning and locating and developing stations were identified as "serving existing commuters based on pre-transit residential and employment patterns" in most (65.1%) cases. "Serving anticipated residents and workers drawn to new development near transit stations" was identified as a goal for almost half the stations (48.0%). Inducing additional transit ridership was identified as an objective for a majority (76.0%) of stations. Relieving roadway congestion was identified as a planning objective in 44.5% of cases. Economic development was identified as a goal for 63.3% of stations. Growth management, environmental, or other public policy mandates or objectives influenced design and development of 30.1% of stations. Transit agency representatives identified political agenda and/or public policy initiatives as driving almost half (48.9%) of stations. (Somewhat surprisingly) initiatives of commercial interests or private developers were identified as driving factors for only two stations (0.9%).

No specific value creation strategies were implemented for 23.1% of stations. Strategic partnership between public and private interests was undertaken in connection with development of 13.1% of stations. Land use, zoning, and entitlement enticement strategies were undertaken in connection with 38.0% of stations. Complementary (supportive/non-transit) public infrastructure investment was undertaken in support of 24.0% of stations. Land assemblage, acquisition, or other real estate strategies were undertaken in connection with 30.1% of stations. Various other value creation strategies were undertaken in connection with 4.8% of stations.

No value capture strategies or mechanisms were employed in the majority (72.5%) of cases. Joint development was undertaken in 12.2% of station areas. Tax Increment Financing (TIF) was employed in 9.6% of cases as were Special Assessments and/or Impact Fees. Naming rights were licensed at 2.2% of stations, and negotiated exactions were imposed at another 2.2%. Land Value Taxation was employed in none of these cases. Although more and more transit agencies may be incorporating forward-looking value capture strategies into early project feasibility and financing analyses, this has not generally been the case. Value capture is often an 11th hour consideration. Failure to consider value capture strategies early on in the process of conceptualizing transit projects may undermine focus on value creation.

Transit agency officials and planning/management staff were asked to rate the importance of several factors in connection with transit station (or transit line) project success. A majority (81.7%) indicated that value capture strategy had not been significantly important to financial viability or project success. On the other hand, many (48.9%) indicated that public-private value creation strategies are significantly important to the success of transit-influenced or transit-oriented development.

Significance and size of effect of station-specific characteristics and transit agency initiatives on variation in differential rates of value creation in proximity to LRT stations

Survey data, received from 12 of 14 subject transit agencies, comprising description of station design, typology, walk-and-ride or park-and-ride character dominance, employment of specific value creation and value capture strategies, and "early" strategic engagement in strategic public-private partnership was evaluated through four mixed ANOVA models to estimate significant and treatment effect attributable to each characteristic.

The hypothesis anticipating this research was that differential rates of aggregate value creation would be influenced by station typology and dominant character, but that results would be inconsistent and highly varied across stations.

Brief telephone interviews with planners and managers of subject transit systems were followed by a survey instrument addressing questions related to station characteristics including station design, typology, and character as well as various transit agency policy objectives, initiatives, and perspectives with respect to value creation and value capture in particular. Planners and/or managers of 12 of 14 subject transit agencies responded to the survey request. A copy of the survey instrument is included below as Appendix I. Descriptive statistics describing survey respondents' responses to question are provided in Appendix V.

CHAPTER 5: SURVEY OF TRANSIT AGENCIES

Transit planners, managers, and executives associated with each of the fourteen subject transit agencies were surveyed during the fall of 2016. A copy of the survey instrument is provided in Appendix I and descriptive statistics describing survey results are provided in Appendix V. These results were employed as variables prospectively explanatory of variation in differential rates of total assessed valuation growth per acre under both ANOVA and panel regression analyses.

Survey respondents provided detailed information about stations including design characteristics, locational typology based on uniform definitions provided to them, and station character (walk-and-ride or park-and-ride). Respondents identified planning and development and/or policy objectives related to subject transit lines. Respondents also provided information about any value creation initiatives undertaken, and/or value capture strategies employed, with respect to subject LRT lines and stations. Respondents were asked to rate the importance of various aspect of value creation strategy and value capture to project success. Finally, respondents were asked open-ended questions regarding the importance of value capture, barriers to successful implementation of value capture, lessons learned, and recommendations regarding value creation and value capture.

An early hypothesis was that individual station-specific characteristics, or such characteristics collectively, and/or transit agency project design/development objectives might shed more light on variation in differential rates of assessed value creation across stations than turned out to be the case. Survey responses provided insight, however, into the limited extent to which transit agencies have engaged in value creation per se', and the very limited role of value capture (within subject transit systems/lines) to date. Transit agencies reported that they and their municipal partners offered few incentives and little affirmative engagement toward value creation proximate to newly developed stations. A general perception was that the market would perceive the economic potential associated with new transit accessibility and respond accordingly. This might be characterized as a perception and belied that "if we build it (transit), they will come." There have been both very significant successes and many disappointments in this regard.

Survey results also suggest that transit agency perspective regarding the relative importance of affirmative value creation strategies and value capture may be evolving and strengthening. Respondents' own words speak clearly and powerfully to these issues.

Representative responses to the question: **"How has the importance of value capture changed over time?"** are as follow:

- "In the early days of development and funding of the existing [project] funding was "plentiful" or at least less competitive and more available at the federal, state and local levels. Given the funding climate at all 3 levels now, there is significant pressure for local agencies and project sponsors to bring more funds to the table and VC - at least as a concept - is rising to a position much higher on the list of possible sources. the financial responsibility is much more at a local level."
- "Given the increasing competitiveness for federal funding over time, value capture has increasingly become an important component to the funding plans for transit infrastructure."
- As federal funding support for high [capacity] transit investments (such as light rail) continues to become a scarcer resource (the New Starts program is currently oversubscribed), states and localities will continue to take on an even greater burden of responsibility for constructing and operating these types of projects. This is especially challenging for state legislatures that have so many

transportation infrastructure needs and projects to fund. Legislators often want [answers to several essential questions] when approached for funding high capacity transit projects. [These include] 1) What will the project do to relieve congestion?, 2) What is the project's return on Investment?, 3) What economic [development] benefits will be derived from the state's investment in a high capacity transit system?, 4) How much transit oriented development will occur?, and 5) How much new tax revenues can be generated from the new TOD projects?"

- "As funding … [has] become more difficult to acquire (especially federal funding), it has become even more important to utilize innovative funding sources, whether it is value capture or PPPs, to ensure your project will be completed."
- "The city … and county both used TIF to provide local match for the construction of the LRT project. This infrastructure investment resulted in significant new development in both locations that increased property values in these two areas… we [increasingly] feel it is right that some of the increased value [resulting from transit development] be used to pay for the investment."
- "We don't] have sales taxes and [some other] tax [revenues] are precluded from being used on transit. So [revenue sources tied to value creation] are very important tool for funding our infrastructure."
- "[Value capture] is becoming more important as a way to implement the regional vision than as a revenue stream."

Representative responses to the question: **What do you perceive to be the greatest barriers to realizing transit-related value capture?** are as follow:

- "Making the [compelling] business case that these funds, especially TIF or impact fees - that would otherwise be spent on other worthy municipal capital improvements or worthy municipal services - should be funneled back into transit. The line between creation of the value and the transit asset is not always straight. The idea of naming rights is less of a struggle from a funding flow perspective but can have other political and local impacts."
- "In our [case] use of TIF funds [is problematic]. Cities already feel they are "giving" funds through [other tax revenues], the idea of additional TIF funds allocated to transit infrastructure is seen as 'double dipping.'"
- "Barriers to transit related value capture [include] coordinating with affected stakeholders and agreeing that increased future tax revenue related to value creation should be spent on transit. With limited funding, the [city] is tapping into more … special districts revenues to fund city projects."
- "The transit agency has no taxing authority."
- "Balancing federal regulatory requirements related to federal dollars being invested in high capacity transit projects, with development strategies that may run afoul of [those] regulatory requirements."
- "[We have very limited" statutory authority to utilize value capture. We are forced to utilize improvements districts, private contributions or partnerships for innovative funding sources."
- "TIF [is perceived as taking funds from] others who use property taxes to fund services [and that they] will have slightly less. These service providers have

raised concerns that they aren't receiving quite as much money since some is being diverted. The other side of the argument is that the increased values would not have happened at the same rate or at all without the investment."

- "Gentrification has occurred [along some lines] in part due to the infrastructure and overall changes in [development patterns]. Gentrification and [the possibility] that property taxes could be used for other service providers is a cause for concern."
- "Legislative and political barriers."

Representative responses to the question: **What lessons has your experience provided with respect to transit infrastructure related value creation and value capture?** are as follow:

- "Value creation and value capture are] very slow process[es] and requires significant education on the front end with stakeholders and elected officials. Making the business case to redirect funds from the municipal general fund remains a challenge. Growth in property taxes, as an example, is usually already imbedded in the municipal budget and revenue growth curve (i.e. the revenues are "spoken for") long before a transit department can try and make the case for value capture if it is not part of the project predevelopment strategy."
- "Value Capture is seen as the transit agency taking funds from [other's] property tax revenue."
- "[Having] analyzed property value growth adjacent to [rail lines, we have] not been able to directly attribute the growth exclusively to the transit infrastructure investment. However, evidence would indicate that there is

definitely a correlation. There have been no value capture agreements with affected stakeholders as a funding mechanism on any of the transit rail projects [we have developed].

Representative responses to the question: **Do you have any suggestions or recommendations for implementing future transit-related value creation and/or value capture projects?** are as follow:

- "Start very, very early with reliable data for what the creation/impacts may be from the proposed project and try to make the case to capture at least some portion - at least for operating costs if not for capital costs. Trying to capture 100% of the value creation is likely a tough sell."
- "[We] will continue to explore alternative funding options as it develops major capital investment transit projects. This will require more coordination with the development, residential and commercial stakeholders."
- "Plan value capture strategies integral to transit project development."

Summary of survey results

In addition to providing details of individual station design, typology, character, and other specifics, transit agency planners and manager provide background concerning planning and development objectives, value creation initiatives, the nature and extent of strategic engagement and/or partnership with other public-sector or private-sector entities, value capture strategies, and agency perspectives regarding the relative importance of these matters to development outcomes and mission success. This feedback was incorporated into ANOVA and panel regression analyses, as described in detail below, with the thought that station-specific characteristics and/or transit agency motivations, initiatives, and perspectives might help explain some part of the significant variation in differential rates of (prospectively) light rail transit infrastructure induced value creation. Although these factors were generally insignificant in predicting such variation, common themes emerged both from formal survey responses and from numerous informal discussions with transit agency planners and managers.

Common themes included the perspective that setting aside pre-development land speculation, too much was expected of private-sector market response to new transit infrastructure investment, absent more affirmative planning and engagement by transit agencies and local government. Many planners and managers perceive that earlier and more significant engagement in the value creation process (beyond purely speculative windfall) is desirable and/or necessary to achieve better and more robust transit-influenced development. This perspective was not universal however. Some planners and manager believe that private-sector development is outside the scope of legitimate concern on their part and that an all but entirely laissez faire approach was most appropriate.

There is broad acceptance of the perspective that as traditional sources of funding for transit projects has become more complicated and difficult to obtain, transit agencies are increasingly looking toward value capture as an important opportunity for closing capital funding gaps. Notwithstanding this, value capture is often an 11^{th}-hour consideration following little preparation or strategic planning for the implementation of effective value capture strategies, or realization of the value creation on which they are dependent. Many planners and managers recognized that earlier and more substantive planning for and engagement in value creation and value capture strategies may be increasingly desirable and/or necessary. More than a few observe that they are not yet institutionally prepared for such undertakings.

CHAPTER 6: RESULTS (ANOVA, non-overlapping treatment areas)

A quasi-experimental design was employed to quantify differences in rates of growth of total assessed value per acre between those within areas of treatment (proximity to 229 LRT stations) and those within areas of control over the 11-year period from 2005 through 2015. Although total assessed value per acre was the metric of primary interest, results for which follow immediately, results of supplementary analyses related to assessed value-land, assessed value-improvements, and folio densities per acre are presented in the "Supplemental Analyses" section.

With respect the first model estimating total assessed value on the basis of the interaction between treatment and time, controlling only for location (transit system) and demographic characteristics:

- ***Total Assessed Value (model 1)***: There was a significant interaction effect between treatment (group) and time; accounting for approximately 2% of the variance in differences in total assessed value per acre over time (difference-in-differences). The interaction effect was significant in the years 2013, 2014, and 2015, as these years represented both a significant change from the year prior, and significant differences between treatment and control groups. Significant covariates included:
    - **Transit system** identifying metropolitan area (market/location) and transit agency (unique locational, and other market characteristics associated with each), accounting for 22% of the differential rate of change in total assessed value per acre over time;
    - **Per capita income** (at the census block-level), accounting for an additional 4% of variation; and
    - **Vehicles per household**, accounting for 2% of variation.

With respect to the four models including all covariates related to station-specific characteristics and transit agency goals, objectives, and strategies:

- ***Total Assessed Value (model 2)***: There was a significant interaction effect between treatment and time in estimating total assessed value, accounting for 2% of the variance in differential rates of change in total assessed value over time. Significant covariates included:
  - **Transit system** (unique locational, perhaps "market" characteristics associated with each), accounting for 19% of the differential rate of change in total assessed value per acre over time;
  - **Per capita income** (at the census block-level), accounting for an additional 3% of variation;
  - **Station design**, accounting for an additional 2% of variation. Stations with an at-grade design were highly correlated with positive differential value creation, and to a much greater extent than stations of other design.
  - **Transit agency perception of public-private value creation strategies as important to the success of transit infrastructure investments and projects**, accounting for an additional 1% of variation; and
  - **Transit agency perception of public-private value creation strategies as important to the success of transit-influenced or transit-oriented development**, accounting for an additional 1% of variation;
- ***Assessed Land Value***: There was a significant interaction between time and treatment in estimating assessed land value, accounting for 1% of the variance in assessed land value. Despite an overall significant interaction effect, however, post hoc analysis indicated that there was not a significant effect when assessed at the

individual year-to-year level. Significant covariates included:

- **Transit system** (unique locational, perhaps "market" characteristics associated with each), accounting for 18% of the differential rate of change in total assessed value per acre over time;
- **Per capita income** (at the census block-level), accounting for an additional 1% of variation;
- **Station design,** accounting for an additional 2% of variation; and
- **Transit agency perception of public-private value creation strategies as important to the success of transit-influenced or transit-oriented development**, accounting for an additional 1% of variation;

- ***Assessed Improvement(s) Value***: There was a significant interaction effect between time and treatment in assessed improvement value, accounting for 2% of the variance in assessed improvement value. None of the five models identified significant interaction effects in every year of observation. The interaction effect on assessed improvement(s) value was significant in seven of the eleven years over which change was measured including: 2006, 2007, 2009, 2012, 2013, 2014, and 2015. This reflects statistical significance over more years of observation than for total assessed value, land assessed value, or folio density. Significant covariates included:
    - **Transit system** (unique locational, perhaps "market" characteristics associated with each), accounting for 18% of the differential rate of change in total assessed value per acre over time;
    - **Per capita income** (at the census block-level), accounting for an additional 3% of variation;

- **Station design** (elevated, at grade, open cut, underground), accounting for an additional 2% of variation;
- **Transit agency perception of public-private value creation strategies as important to the success of transit infrastructure investments and projects**, accounting for an additional 1% of variation;
- **Transit agency perception of public-private value creation strategies as important to the success of transit-influenced or transit-oriented development**, accounting for an additional 1% of variation; and
- **Median household income**, accounting for an additional 1% of variation.

- ***Folio Density***: There was a significant interaction effect between time and treatment in folio counts, accounting for 2% of the variance in folio accounts. Interaction effects were significant in years 2009, 2012, 2013, 2014, and 2015 specifically, as these years represented both a significant change from the year prior, and significant differences between treatment and control groups. Significant covariates included:
  - **Transit system** (unique locational, perhaps "market" characteristics associated with each), accounting for 7% of the differential rate of change in total assessed value per acre over time;
  - **Per capita income** (at the census block-level), accounting for an additional 2% of variation;
  - **Transit agency perception of public-private value creation strategies as important to the success of transit-influenced or transit-oriented development,** accounting for an additional 1% of variation; and
  - **Size of household**, accounting for an additional 1% of variation.

Total Assessed Value

Within the 10-year period from 2005 through 2015, total assessed value per acre within 229 subject treatment areas rose from an average of $431,514 to $973,047, an increase of 125%, or an average annually compounded rate of 8.47%. Within corresponding control areas, total assessed value per acre rose from an average of $407,928 to $686,651, an increase of 68%, or an average annually compounded rate of 5.35% Figure 10 depicts the difference in total assessed value per acre over the period. Total assessed value per acre grew at an average annually compounded rate of 3.13% faster within TAI treatment areas than within corresponding control areas.

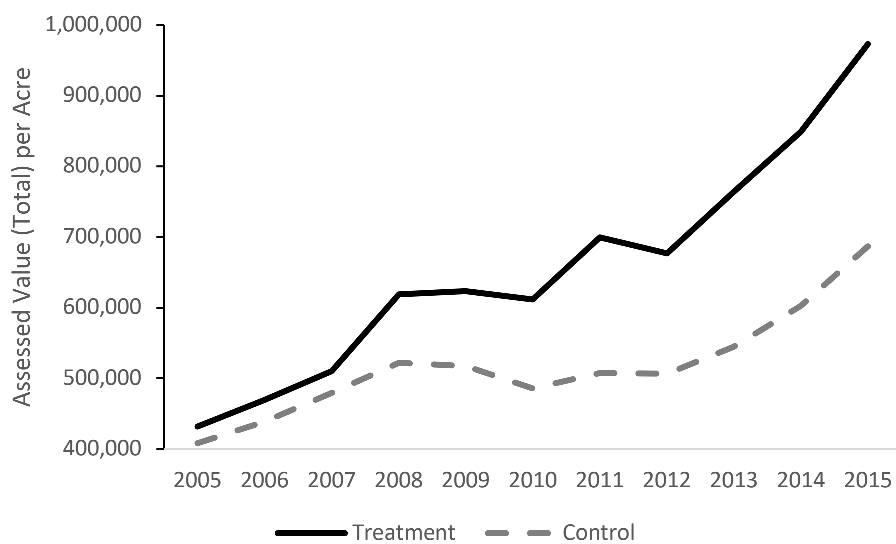


Figure 11:(Unadjusted) Mean Total Assessed Value Per Acre

This average aggregate rate of differential value creation associated with proximity to LRT stations cannot be usefully generalized, however. Consistent with the hypothesis, but to an even greater extent than anticipated, differential rates of total assessed value creation were highly varied across transit lines and stations. Stations within the 20% of transit systems exhibiting the highest rates of increase in total assessed total values per acre within treatment areas over time experienced an average increase of 306.72% over the period. Whereas stations within the 20% of transit systems exhibiting the lowest rates of increase in total assessed total values per acre within treatment areas over time experienced an average decrease of 12.46%.

Although differential value creation rates of stations within the second and third quintile were also positive, these rates were very highly skewed. High rates of differential value creation occurred most markedly only in the first quintile. Differential rates of total assessed value creation in the other 80% of stations could fairly be described as “flat,” as illustrated in Figure 11.

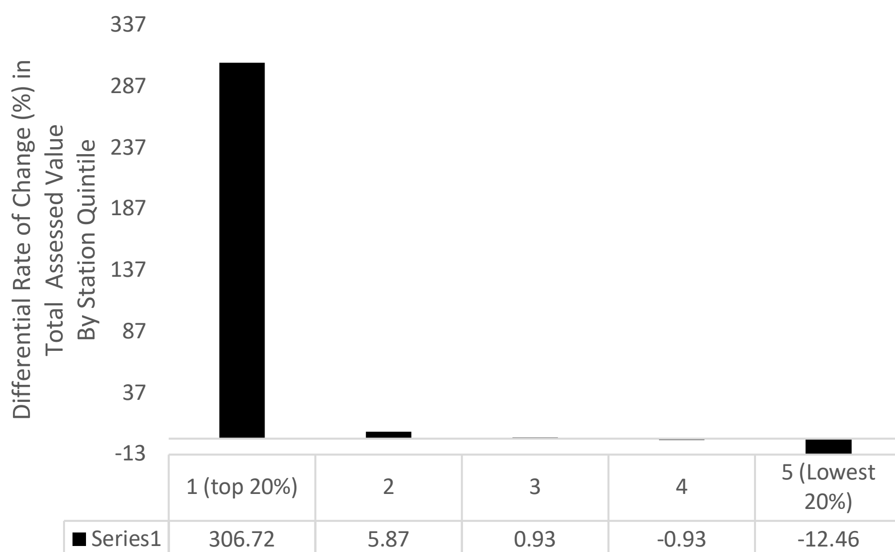


Figure 12: Differential (mean) rates of change in total assessed value over time, by quintile.

Sorted by transit system rather than individual station, rates of value creation were also very highly skewed.Transit systems experiencing the greatest differential rates of change in total assessed value between treatment and control over the period included those in Phoenix and Salt Lake City. Those with the lowest differential rates of change between treatment and control over the 11-year period included those in Denver, Los Angeles, Charlotte, Minneapolis, and San Diego, as illustrated in the Figure 12.

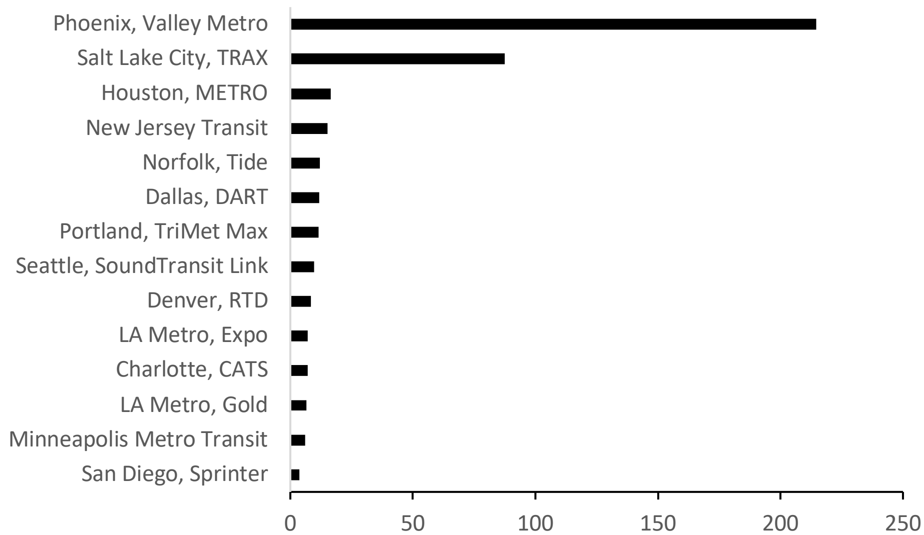


Figure 13: Mean differential rates of change in Total Assessed Value by System

Heterogeneity in differential assessed value creation within systems.

Not only did differential rates of total assessed value creation vary significantly across transit systems, these rates were highly heterogeneous within systems. The same was true for assessed values of land and improvements, and for changes in folio density. Even along a single transit line where differential value creation over the 10-year period was very high for some stations, it was effectively flat or negative for others. The 13-stations studies within Charlotte's CATS Blue Line provide an illustrative example. Total assessed value per acre within Transit Areas of Influence within the 13-station areas increased 146% from 2005 through 2015, whereas total assessed value per acre increased only 54% within surrounding control areas over the same period. Total assessed value per acre increased 92% more in Charlotte's treatment areas than in control areas. These results were very uneven across individual stations, however. Four of the Blue Line stations experienced differential assessed value creation per acre of more than 100% over the period; three station areas experienced differential total assessed valuation increases of between 14% and 62% over the period; and the remaining six station areas experienced negligible or negative differential value creation over the period.

Such variation between station areas was common along many of the subject transit lines and within most of the transit systems. Only the Red Line in Salt Lake City experienced uniformly positive differential total assessed valuation growth per acre over the period of study. The Metro Blue Line in Minneapolis and the RTD Purple Line in Denver each had only a single station area with negative differential total assessed value creation. A relatively few station areas experiencing very high rates of differential value creation account for the aggregate average increase of more than 50% over the period.

This study was concerned with differential rates of assessed value creation between Transit Areas of Influence (treatment areas) and surrounding control areas. Of the transit systems studied, Seattle is the outlying case of very high levels of absolute total assessed value increases per acre both within treatment and control areas, resulting in low differential rates of assessed value creation per acre. In some cases, values increased significantly faster within treatment areas than within control areas and surrounding other stations just the opposite was true.

Treatment effect – significance and magnitude

The first mixed model ANOVA estimated the effects of time, treatment, and the interaction between the time and treatment controlling only for location (transit system) and various demographic covariates. Total assessed value was regressed on a broad array of demographic characteristics to identify and eliminate variables with significant collinearity. The resulting list of demographic (control) covariates includes the following at the census tract-level; median household income, per capita income, total vehicles per household, percent of dwellings vacant, percent of dwellings owner occupied, cars per owner occupied household, persons per household, and gross rent burden greater than 30%.

Main and interaction effects of this first mixed ANOVA analysis are as follow:

Main Effects. The main effect of time was significant, $F(1.72, 746.48)$, $p = .0.41$, $\eta^2_{partial} = .01$. This indicates that, controlling for location (transit system) and demographic covariates, there were significant differences in total assessed value per acre from year to year between 2005 and 2015. The main effect of group (treatment and control) was significant, $F(1, 433) = 4.37$, $p = .041$, $\eta^2_{partial} = .01$. This indicates that, when controlling for location and demographic characteristics, there is a significant difference between treatment and control areas, but that this effect accounted for only approximately 1.0% of the variance in total assessed total value per acre, exclusive of the interaction of treatment and time (based on the Eta squared [η^2 partial] statistic).

> Eta squared [η^2] measures the proportion of the total variance in a dependent variable that is associated with the membership of different groups defined by an independent variable. Partial eta squared [$\eta^2_{partial}$] is a similar measure in which the effects of other independent variables and interactions are partialled out. (Richardson, 2011)

Table 2: ANOVA Source Table, Total Assessed Value (1), Between Subjects

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Treatment	1.00	4.37	.037	.01
Error	433.00	-	-	-

Covariates. Significant covariates included transit system, $F(130, 746.48) = 9.32$, $p < .001$, $\eta^2_{partial} = .22$, per capita income, $F(1.72, 746.48) = 15.68$, $p < .001$, $\eta^2_{partial} = .04$), and vehicles per household, $F(1.72, 746.48) = 6.63$, $p < .002$, $\eta^2_{partial} = .02$), These eta squared-partial results suggest that prior to controlling for individual station-specific characteristics, 22% of the differential rate of change in total assessed value per acre over time (11-years) can be explained by the unique locational (perhaps "market") characteristics associated with each transit system. An additional 4%

of this variation is explained by variation in per capita income levels at the census block-level, and 2% by the number of vehicles per household.

Interaction effect. There was a significant interaction between time and treatment group, $F(1.72, 746.48) = 10.31$, $p < .001$, $\eta^2_{partial} = .02$, as reflected in Table 3, indicating that there were significant differences in rates of change in total assessed value per acre between treatment and control groups over time, while controlling only for location (transit system) and demographic covariates; and that the "treatment effect" accounted for approximately 2% of the variance in differences in total assessed value per acre over time (difference-in-differences).

Table 3: ANOVA Source Table, principal treatment effect, Total Assessed Value (1)

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Time	1.72	3.39	.041	.01
Time x Treatment	1.72	10.31	< .001	.02
Time x Median Household Income	1.72	2.79	.070	.01
Time x Per Capita Income	1.72	15.68	< .001	.04
Time x Cars per Household	1.72	6.63	.002	.02
Time x Percent Houses Vacant	1.72	0.87	.404	.00
Time x Percent Houses Owner Occupied	1.72	1.21	.296	.00
Time x Cars per Owner Occupied Household	1.72	0.50	.578	.00
Time x Household Size	1.72	2.77	.072	.01
Time x Rent Burden >30%	1.72	0.51	.573	.00
Time x System	130.00	9.32	< .001	.22
Error	746.48	-	-	-

Station characteristics - significance and magnitude

Following estimation of the significance and magnitude of the principal treatment (proximity to LRT stations) effect on differential rates of total assessed value creation, station-specific characteristics were evaluated for association with variation in treatment effect between stations. Station-specific characteristics fell into two general classes. The first of these consisted of physical and function characteristics of stations such as station design, (locational) typology, (walk-and-ride or park-and-ride) character, and number of transit agency-provided parking spaces. The second class of characteristics was comprised of a) transit agency goals and objectives driving planning/development of subject transit line and station areas; b) value creation strategies employed in connection with transit line/station planning and development; c) value capture mechanisms employed as part of the infrastructure funding strategy; and d) significance or importance of value capture strategy to various aspects of project success. Specific questions associated with each of these inquiries are identified in the survey instrument provided as Appendix I.

Main and interaction effects of this second mixed ANOVA analysis, as reflected in Table 4, are as follow:

Main Effects. The main effect of time was not significant, $F(1.72, 718.04) = 47.31$, $p = .190$, $\eta^2_{partial} = .02$. This indicates that, when controlling for all other effects, there were not significant differences in assessed total value per acre from year to year between 2005 and 2015. The main effect of group (treatment and control) was significant, $F(1, 418) = 4.39$, $p = .037$, $\eta^2_{partial} = .01$. This indicates that, when controlling for all other effects, there is a significant difference between treatment and control areas, but that this effect accounted for only approximately 1.0% of the variance in total assessed total value per acre, exclusive of the interaction of treatment and time.

Table 4: ANOVA Source Table, Total Assessed Value (2), Between Subjects

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Treatment	1.00	4.39	.037	.01
Error	418.00	-	-	-

Covariates. Significant covariates included per capita income, $F(1.72, 718.04) = 11.01$, $p < .001$, $\eta^2_{partial} = .03$), importance of public-private value creation strategies to the success of transit-influenced or transit-oriented development, $F(1.72, 718.04) = 5.92$, $p = .005$,

$\eta^2_{partial}$ = .01, importance of public-private value creation strategies to the success of transit infrastructure investments and projects, $F(1.72, 718.04) = 6.06$, $p = .004$, $\eta^2_{partial}$ = .01, station design, $F(5.15, 718.04) = 2.48$, $p = .029$, $\eta^2_{partial}$ = .02 and station system, $F(22.33, 718.04) = 7.31$, $p < .001$, $\eta^2_{partial}$ = .19. This suggests that per capita income, importance of public-private value creation strategies to the success of transit-influenced or transit-oriented development, importance of public-private value creation strategies to the success of transit infrastructure investments and projects, station design, and station system significantly associated with assessed total value over time, account for variance as indicated by the partial eta squared statistic for each.

Interaction effect. There was a significant interaction between time and treatment group, $F(1.72, 718.04) = 10.42$, $p < .001$, $\eta^2_{partial}$ = .02, indicating that there were significant differences in rates of change in assessed total value per acre between the treatment and control groups over time, while controlling for the covariates, accounting for approximately 2% of the variance in differences in assessed total value per acre (i.e., difference-in-differences). Figure 13 reflects estimated marginal means of values of total assessed value within treatment and control groups over time adjusted for all covariates.

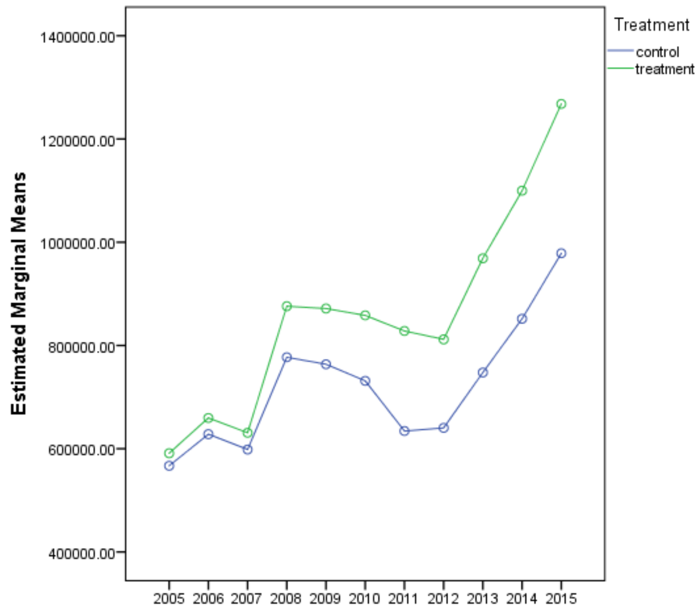


Figure 14: Estimated Marginal Means, Total Assessed Value

Estimated Marginal Means

Estimated marginal means as reflected in Figures 13, 17, 21, and 24 presented for each of the four fully controlled models reported in this study represent the estimated mean values for each subject dependent variable (in each year), controlled for each of the covariates in each model. These are the means of dependent variables estimated using the mean values of each of the covariates. Actual mean values for each dependent variable are estimated (adjusted) based on the mean values of the (17) covariates in each model.

Table 5: ANOVA Source Table, Station Characteristics, Total Assessed Value (2), Within-Subjects

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Time	1.72	1.69	.190	.00
Time x Treatment	1.72	10.42	.000	.02
Time x Median Household Income	1.72	2.68	.078	.01
Time x Per Capita Income	1.72	11.01	.000	.03
Time x Cars per Household	1.72	1.58	.209	.00
Time x Percent Houses Vacant	1.72	0.95	.375	.00
Time x Percent Houses Owner Occupied	1.72	0.66	.493	.00
Time x Cars per Owner Occupied Household	1.72	0.77	.447	.00
Time x Household Size	1.72	0.33	.687	.00
Time x How significant/important was value capture strategy to financial viability or project success?	1.72	1.22	.291	.00
Time x How important are public-private value creation strategies to the success of transit-influenced or transit-oriented development?	1.72	5.92	.005	.01
Time x How important are public-private value creation strategies to the success of transit infrastructure investments and projects?	1.72	6.06	.004	.01
Time x How important is value capture to the success of transit infrastructure investments and projects?	1.72	0.59	.531	.00
Time x Rent Burden >30%	1.72	0.40	.637	.00
Time x Parking Spaces	1.72	0.47	.598	.00
Time x Station Design	5.15	2.48	.029	.02
Time x Station Typology	10.31	0.42	.943	.01
Time x System	22.33	7.31	.000	.19
Time x Character	1.72	0.66	.496	.00
Error	718.04	-	-	-

Supplemental Analyses

Assessed Value-Land

Prospectively differential rates of change in the assessed values of land (as opposed to that of improvements) over time is of some interest due to theory that economic benefits of mobility and accessibility resulting from proximity to transit stations (or that associated with other beneficial public infrastructure investment) will be capitalized into the market value of land in particular. The theoretical assumption that such benefits will accrue to land values per se is much of the rationale supporting land value taxation (Bryson, 2011; George, 1879).

Aggregate totals of assessed value-land within each geographic treatment and control area were divided by the acreage in each area resulting in values per acre to facilitate level comparison. Assessed value-land within 229 subject treatment areas rose from an average (mean) of $145,805 per acre in 2005 to $290,895 per acre in 2015, an increase of 100% over the period, or an average annual rate of 9.95%. Within corresponding control areas, total assessed value per acre rose from an average of $156,783 per acre to $261,357 per acre, increasing at an average annual rate of 6.67%. Across all 229 stations, total assessed valuation per acre within transit treatment areas increased at an average rate of 3.28% per year faster than that within control areas as illustrated in Figure 14. These results were highly varied across transit lines and stations, however.

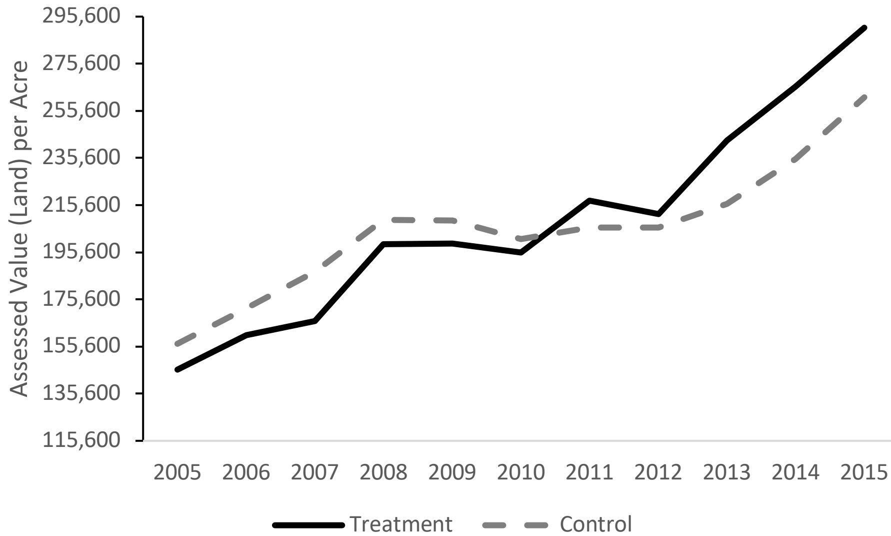


Figure 15: Mean Assessed Value-Land per acre

Although differences between aggregate rates of assessed land value creation over time were only modest, even these were highly varied across stations. The average aggregate rate of differential assessed land value creation associated with proximity to LRT stations within the 20% of transit systems exhibiting the highest rates of increase in assessed value-land within treatment areas over time experienced an average increase of 191.7% over the period, or an average annual rate of 19.17%. Whereas stations within the 20% of transit systems exhibiting the lowest rates of increase in assessed value-land within treatment areas over time experienced an average decrease of 28.24% over the period, or an average annual rate of negative 2.82%, as illustrated in Figure 15.

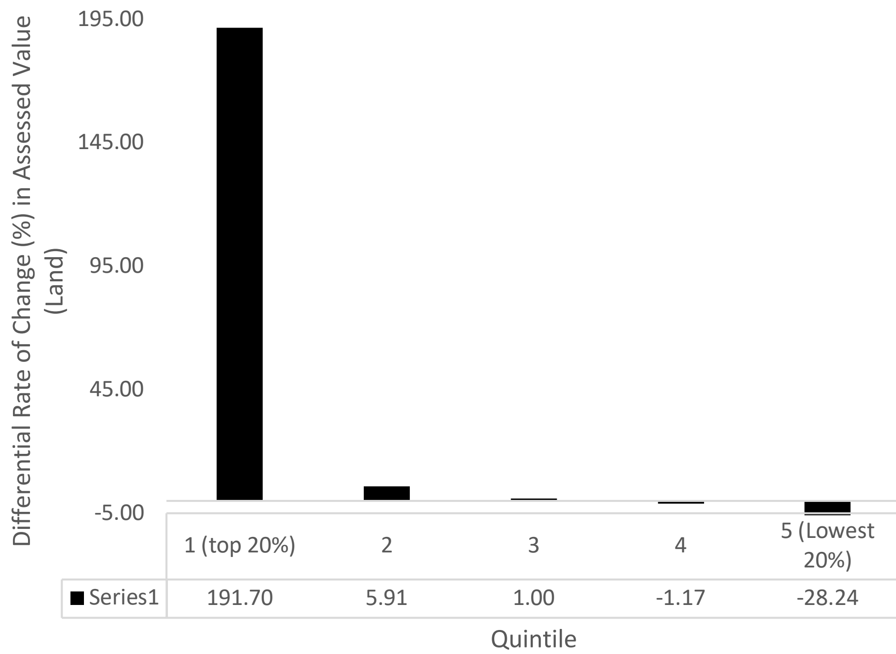


Figure 16: Differential (mean) rates of change in assessed land value over time, by quintile.

Sorted by transit system rather than individual station, differential rates of value creation were much less skewed (and all positive), but still highly varied. Transit systems experiencing the greatest differential rates of change in total assessed value between treatment and control over the period included those in Salt Lake City and Denver. Those with the lowest differential rates of change between treatment and control over the 11-year period included those in Charlotte, Los Angeles, Minneapolis, and San Diego, as illustrated in Figure 16.

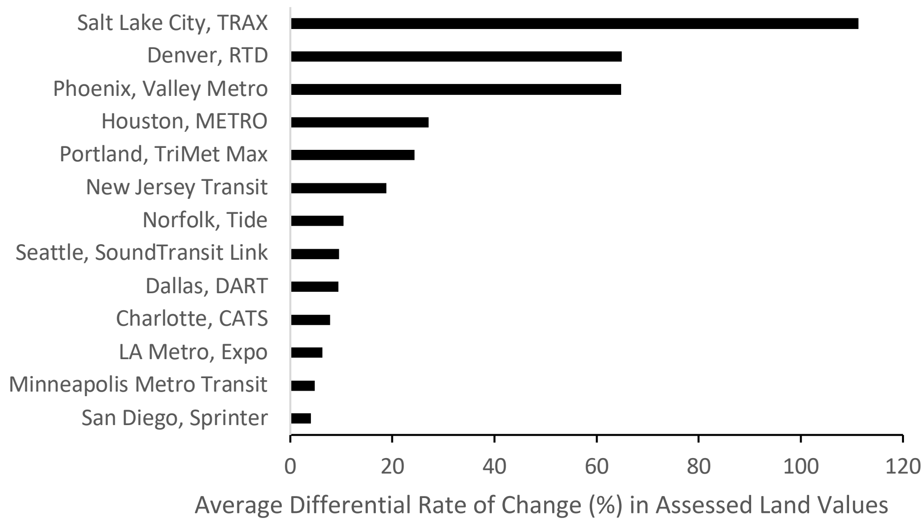


Figure 17: Mean differential rates of change in Assessed Land Value by System

Mixed model ANOVA was used to determine the effects of treatment, time, and the interaction between the two on assessed value–land as the dependent variable. Main and interaction effects of this analysis are as follow.

Main Effects. The main effect of time was not significant, $F(1.69, 704.34) = 2.25$, $p = .116$, $\eta^2_{partial} = .01$. See Table 6. This suggests that, when controlling for all other effects, there were no significant global differences in assessed land values per year per acre during the time period of 2005 to 2015. The main effect of group was not significant, $F(1, 418) = 0.05$, $p = .832$, $\eta^2_{partial} = .00$. This indicates that, when controlling for all other effects, there is not a significant difference between treatment and control areas.

Table 6: ANOVA Source Table for Assessed Land Value per Acre, Between-Subjects

Source	*SS*	*df*	*MS*	*F*	*p*	$\eta^2_{partial}$
Treatment	18522372670.00	1.00	18522372670.00	0.05	.832	.00
Error	171467944300000.00	418.00	410210393000.00	-	-	-

Covariates. Significant interactions with covariates included per capita income, $F(1.69, 704.34) = 3.44$, $p = .040$, $\eta^2_{partial} = .01$, importance of public-private value creation strategies to the success of transit-influenced or transit-oriented development, $F(1.69, 704.34) = 5.14$, $p = .009$, $\eta^2_{partial} = .01$, and station system, $F(21.1, 704.34) = 5.56$, $p < .001$, $\eta^2_{partial} = .15$. This indicates that per capita income, importance of public-private value creation strategies, and type of station system significantly influenced assessed land value over time, accounting for up to 15% (in the case of station system) of the variation in assessed land value.

Interaction effect. There was a significant interaction between time and treatment group, $F(1.69, 704.34) = 4.34$, $p = .019$, $\eta^2_{partial} = .01$, indicating that there were significant differences in rates of assessed land values per acre between the treatment and control groups over time, while controlling for the covariates (i.e., difference-indifferences). The partial eta squared coefficient indicates that approximately 1% of the variation in differences in assessed land value can be attributed to this interaction. The interaction effect was not significant in any individual year. The following figure reflects estimated marginal means of values of assessed value–land within treatment and control groups over time adjusted for all covariates.

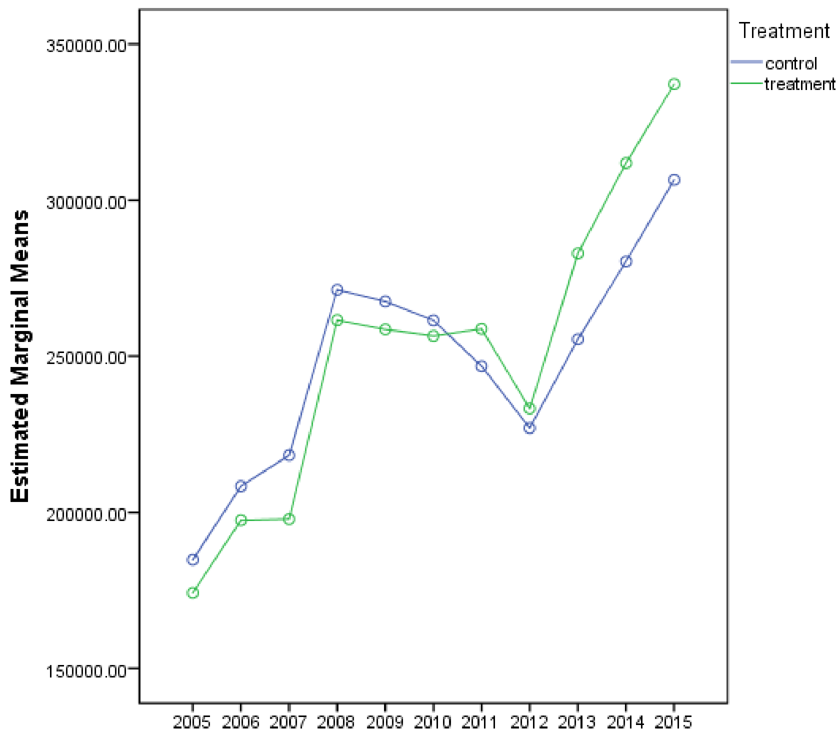


Figure 18: Estimated Marginal Means, Assessed Value – Land

Table 7: ANOVA Source Table, Station Characteristics, Assessed Land Value, Within-Subjects

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Time	1.69	2.25	.116	0.01
Time x Treatment	1.69	4.34	.019	0.01
Time x Median Household Income	1.69	0.96	.370	0.00
Time x Per Capita Income	1.69	3.44	.040	0.01
Time x Cars per Household	1.69	0.48	.585	0.00
Time x Percent Houses Vacant	1.69	0.20	.781	0.00
Time x Percent Houses Owner Occupied	1.69	0.57	.536	0.00
Time x Cars per Owner Occupied Household	1.69	0.99	.360	0.00
Time x Household Size	1.69	0.66	.493	0.00
Time x How significant/important was value capture strategy to financial viability or project success?	1.69	0.61	.518	0.00
Time x How important are public-private value creation strategies to the success of transit-influenced or transit-oriented development?	1.69	5.14	.009	0.01
Time x How important are public-private value creation strategies to the success of transit infrastructure investments and projects?	1.69	2.96	.062	0.01
Time x How important is value capture to the success of transit infrastructure investments and projects?	1.69	0.52	.564	0.00
Time x Rent Burden >30%	1.69	0.34	.674	0.00
Time x Parking Spaces	1.69	0.64	.501	0.00
Time x Station Design	5.06	1.72	.128	0.01
Time x Station Typology	10.11	1.56	.115	0.02
Time x System	21.91	5.56	.000	0.15
Time x Character	1.69	0.85	.413	0.00
Error	704.34	-	-	-

Assessed Value-Improvements

As for assessed value-land, aggregate totals of assessed value-improvements within each geographic treatment and control area were divided by the acreage in each area resulting in values per acre to facilitate level comparison.

Assessed value-improvements within 229 subject treatment areas rose from an average (mean) of $310,779 per acre in 2005 to $681,866 per acre in 2015, an increase of 119% over the period, or an average annual rate of 11.94%. Within corresponding control areas, total assessed value per acre rose from an average of $241,687 per acre to $425,216 per acre, increasing at an average annual rate of 7.59%. Across all 229 stations, total assessed valuation per acre within transit treatment areas increased at an average rate of 4.35% per year faster than that within control areas, as illustrated in Figure 18.

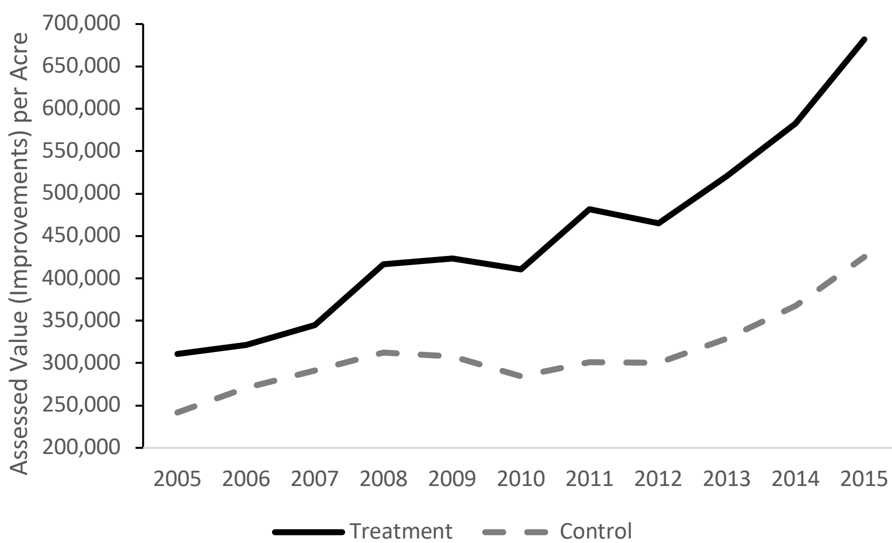


Figure 19: Mean Assessed Improvement(s) Value per acre

These values were highly varied across stations. The average aggregate rate of differential assessed improvement value creation associated with proximity to LRT stations within the 20% of transit systems exhibiting the highest rates of increase in assessed improvement(s) value within treatment areas over time experienced an average increase of 223.93% over the period, or an average annual rate of 22.39%. Whereas stations within the 20%

of transit systems exhibiting the lowest rates of increase in assessed value-improvements within treatment areas over time experienced an average <u>decrease</u> of 23.87% over the period, or an average annual rate of -2.39%, as illustrated in Figure 19.

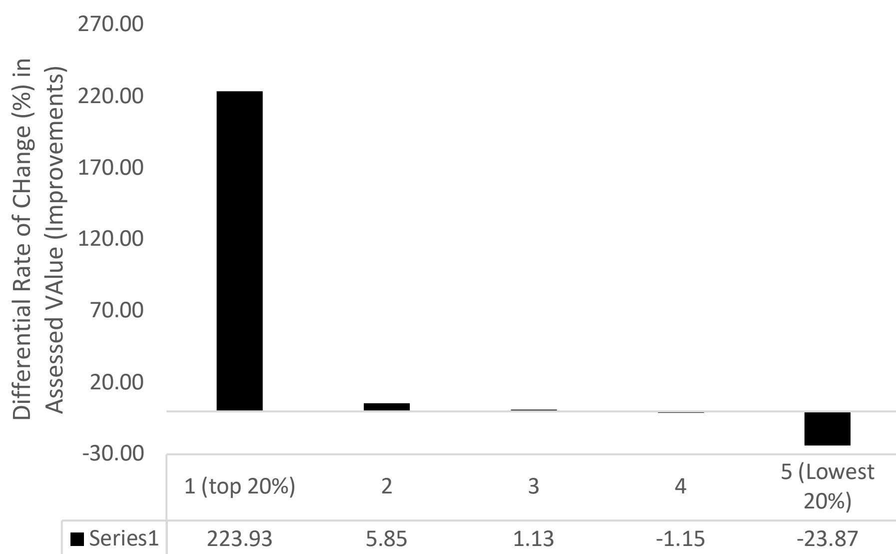


Figure 20: Differential (mean) rates of change in assessed improvement(s) value over time, by quintile.

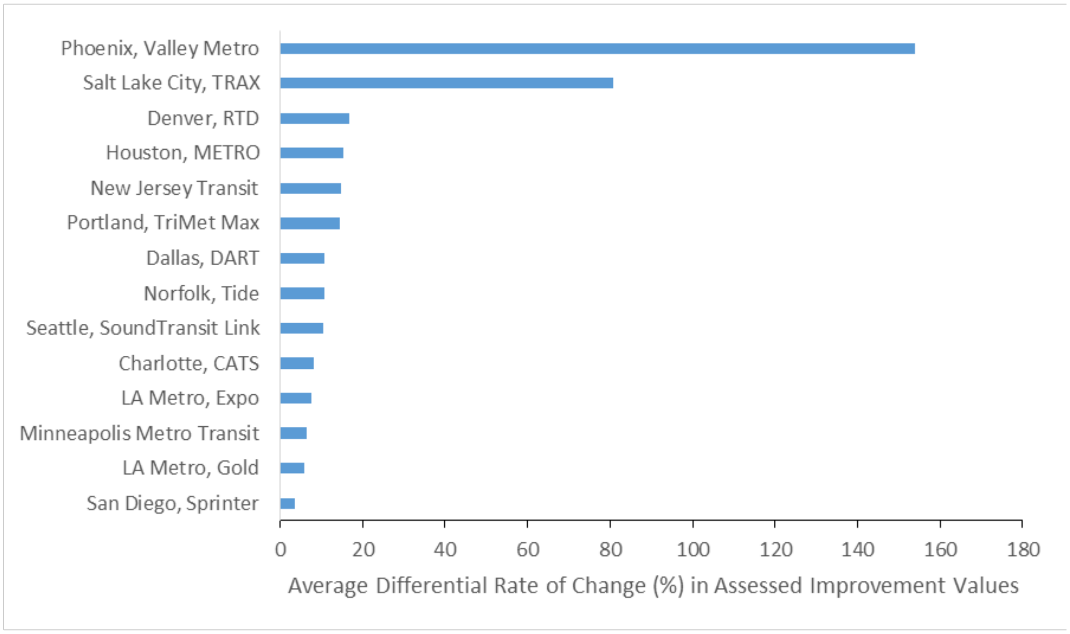


Figure 21: Mean differential rates of change in Assessed Improvement(s) Value by System

Mixed model ANOVA was used to determine the effects of treatment, time, and the interaction between the two on assessed value–improvements as the dependent variable. Main and interaction effects of this analysis are as follow:

Main Effects. The main effect of time was not significant, $F(2.25, 941.44) = 1.11$, $p = .335$, $\eta^2_{partial} = .00$. This indicates that, when controlling for all other effects, there were no significant differences in assessed improvement value per acre from year to year between 2005 and 2015. The main effect of group (treatment and control) was significant, $F(1, 418) = 7.42$, $p = .007$, $\eta^2_{partial} = .02$. This indicates that, when controlling for all other effects, there is a significant difference between treatment and control areas, which explains approximately 2% of the variance in folio counts per acre, as reflected in Table 8. On average, treatment areas had 139924.2 more assessed improvement value per acre than control areas.

Table 8: ANOVA Source Table for Assessed Value - Improvements per Acre, Between-Subjects

Source	*SS*	*df*	*MS*	*F*	*p*	$\eta^2_{partial}$
Treatment	24551800260000.00	1.00	24551800260000.00	7.42	.007	.02
Error	1383574070000000.00	418.00	3309985812000.00	-	-	-

Covariates. Significant covariates included median household income, $F(2.25, 941.44) = 3.18$, $p = .036$, $\eta^2_{partial} = .01$, per capita income, $F(2.25, 941.44) = 12.73$, $p < .001$, $\eta^2_{partial} = .03$, importance of public-private value creation strategies to success of transit-influenced or transit-oriented development, $F(2.25, 941.44) = 4.60$, $p = .008$, $\eta^2_{partial} = .01$, importance of public-private value creation strategies to success of transit infrastructure investments and projects, $F(2.25, 941.44) = 5.24$, $p = .004$, $\eta^2_{partial} = .01$, station design, $F(6.76, 941.44) = 2.11$, $p = .042$, $\eta^2_{partial} = .02$, and station system, $F(6.76, 941.44) = 6.89$, $p < .001$, $\eta^2_{partial} = .18$. This indicates that median household income, importance of public-private value creation strategies to success of transit-influenced or transit-oriented development, importance of public-private value creation strategies to success of transit infrastructure investments and projects, station design, and station system share variance with the dependent variable, up to the amount indicated by the partial eta squared statistic.

Interaction effect. There was a significant interaction between time and treatment group, $F(2.25, 941.44) = 8.93$, $p < .001$, $\eta^2_{partial} = .02$, indicating that there were significant differences in the rate of assessed improvement per acre between the treatment and control groups over time, while controlling for the covariates (i.e., a difference-in-differences). This effect accounted for approximately 2% of the variance in differences in assessed improvement values per acre. The following figure reflects estimated marginal means of values of assessed value–improvements within treatment and control groups over time adjusted for all covariates.

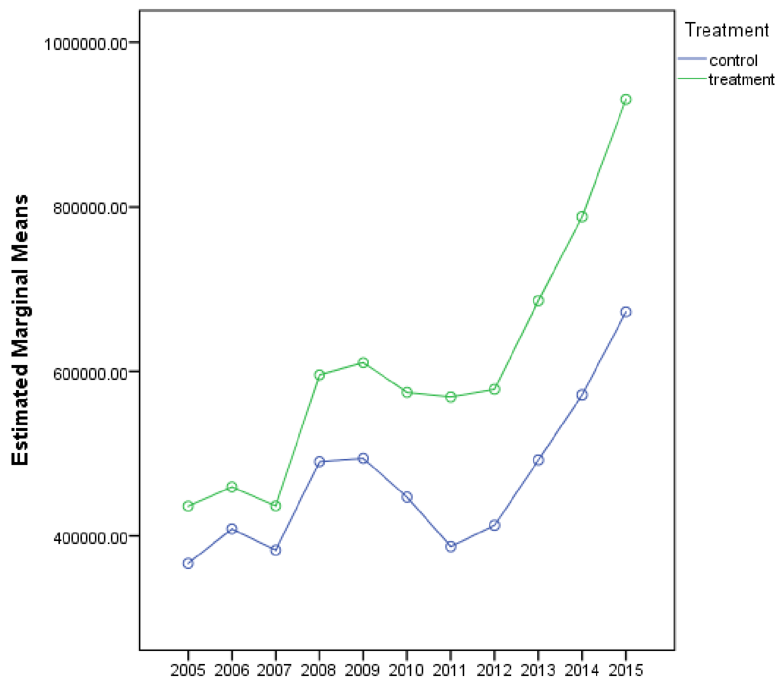


Figure 22: Estimated Marginal Means, Assessed Improvement(s) Value

Table 9: ANOVA Source Table, Assessed Value-Improvements, Within-Subjects

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Time	2.25	1.11	.335	.00
Time x Treatment	2.25	8.94	.000	.02
Time x Median Household Income	2.25	3.18	.036	.01
Time x Per Capita Income	2.25	12.73	.000	.03
Time x Cars per Household	2.25	2.36	.088	.01
Time x Percent Houses Vacant	2.25	2.34	.090	.01
Time x Percent Houses Owner Occupied	2.25	0.65	.540	.00
Time x Cars per Owner Occupied Household	2.25	0.95	.396	.00
Time x Household Size	2.25	0.66	.536	.00
Time x How significant/important was value capture strategy to financial viability or project success?	2.25	1.05	.357	.00
Time x How important are public-private value creation strategies to the success of transit-influenced or transit-oriented development?	2.25	4.60	.008	.01
Time x How important are public-private value creation strategies to the success of transit infrastructure investments and projects?	2.25	5.24	.004	.01
Time x How important is value capture to the success of transit infrastructure investments and projects?	2.25	0.52	.617	.00
Time x Rent Burden >30%	2.25	1.16	.319	.00
Time x Parking Spaces	2.25	0.34	.738	.00
Time x Station Design	6.76	2.11	.042	.02
Time x Station Typology	13.51	0.24	.998	.00
Time x System	29.28	6.89	.000	.18
Time x Character	2.25	0.96	.392	.00
Error	941.44	-	-	-

Folio Density

The rate of change of folio density over time is of some interest because of the tendency for parcels to be subdivided as development occurs (hence "subdivision"). While the opposite may occur when, for example, a developer assembles multiple previously subdivided parcels to accommodate a large multifamily (rental) or office project, it *may* be the case that condominium and other similar development often results in greater parcelization and increasing folio density overtime. This may be the case, in particular, given the nature of transit-oriented and transit-influenced development that frequently accompanies new transit system development.

The "folio count" comprised the discrete number of ad valorem real estate tax accounts in each geographic treatment or control area. Folio counts were divided by the acreage in each corresponding treatment or control area resulting in a folio count per acre (folio density) to facilitate level comparison. Folio densities per acre within 229 subject treatment areas rose from an average of 1.89 in 2005 to 2.32 in 2015, an increase of 22.75% over the period, or an average annual rate of 2.28%. Within corresponding control areas, folio density per acre rose from an average of 1.67 to 1.88, increasing at an average annual rate of 1.26%. Across all 229 stations, total assessed valuation per acre within transit treatment areas increased at an average rate of 1.02% per year faster than that within control areas. These results were highly varied across transit lines and stations.

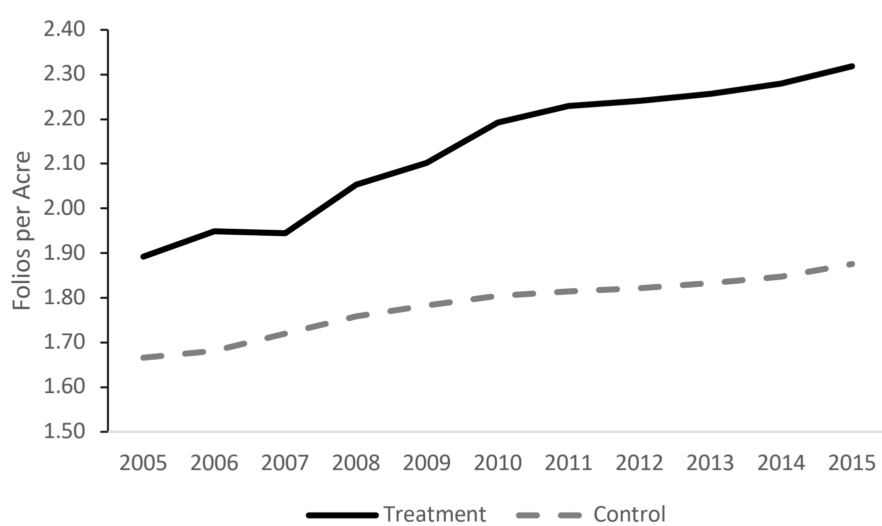


Figure 23: Mean Folio Densities per acre

The average aggregate rate of differential folio density creation associated with proximity to LRT stations cannot be generalized, however. Differential rates of folio creation per acre were highly varied across transit lines and stations. Stations within the 20% of transit systems exhibiting the highest rates of increase in folio density within treatment areas over time experienced an average increase of 469.79% over the period, or an average annual rate of 46.98%. Whereas stations within the 20% of transit systems exhibiting the lowest rates of increased folio density within treatment areas over time experienced an average <u>decrease</u> of 188.8% over the period, or an average annual rate of -18.88%.

Differential folio creation rates of stations within the second, third, and fourth quintiles were effectively "flat," as illustrated in Figure 23.

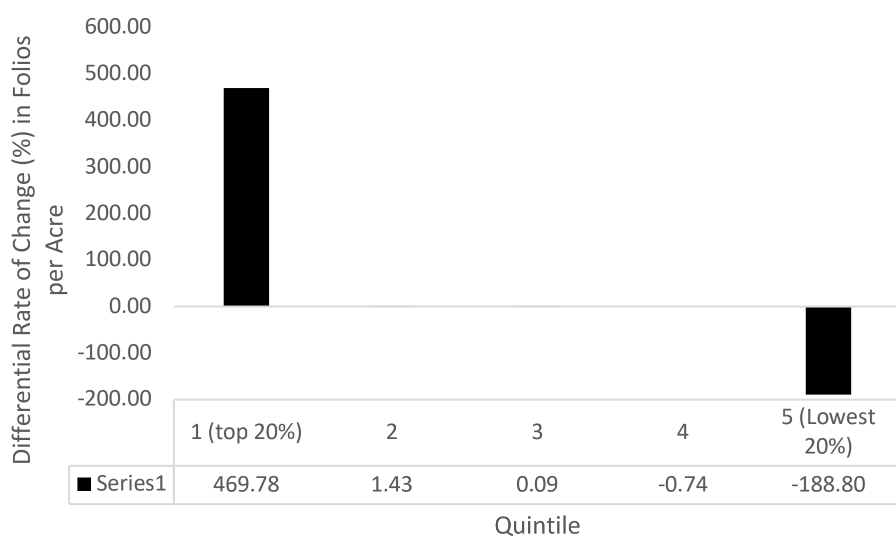


Figure 24: Differential (mean) rates of change in total assessed value over time, by quintile.

Mixed model ANOVA was used to examine both within (i.e., time) and between (i.e., treatment) effects, in addition to the interaction, which describes the effect of treatment over time. Main and interaction effects of this analysis are as follow.

Main Effects. The main effect of time was not significant, $F(1.99, 833.08) = 2.05$, $p = .130$, $\eta^2_{partial} = .01$. This indicates that, when controlling for all other effects, there were no significant differences in folio counts per acre from year to year during the 2005 to 2015 period overall. The main effect of group (treatment and control) was significant, $F(1, 418) = 7.73$, $p = .006$, $\eta^2_{partial} = .02$. This indicates that, when controlling for all other effects, there is a significant difference between treatment and control areas during the study period. The partial eta squared statistic ($\eta^2_{partial}$) suggests that the effect of treatment group accounts for approximately 2% of the variance in folio counts per acre. Overall, treatment areas had 0.36 higher folio counts per acre than control areas.

Table 10: ANOVA Source Table for Folio Density (counts per acre), Between-Subjects

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Treatment	1.00	7.73	.006	.02
Error	418.00	-	-	-

Covariates. Covariates with a significant interaction with time included per capita income, $F(1.99, 833.08) = 7.09$, $p = .001$, $\eta^2_{partial} = .02$, household size, $F(1.99, 833.08) = 3.00$, $p = .050$, $\eta^2_{partial} = .01$, importance of public private value creation strategies to transit-influenced or transit-oriented development success, $F(1.99, 833.08) = 4.50$, $p = .011$, $\eta^2_{partial} = .01$, and station system, $F(1.99, 833.08) = 2.29$, $p < .001$, $\eta^2_{partial} = .07$. This indicates that per capita income, household size, importance of public-private value creation strategies, and system accounted for up to 2%, 1%, 1%, and 7% of the variability in folio counts per acre over time, respectively.

Interaction effect. There was a significant interaction between time and treatment group, $F(1.99, 833.08) = 6.74$, $p = .001$, $\eta^2_{partial} = .02$, indicating that there were significant differences in folio counts per acre over time depending on whether an observation resulted from the treatment or control groups (i.e., significant difference-in-differences), while controlling for the covariates. The partial eta squared coefficient indicates that approximately 2% of the variance in differences in folio counts can be attributed to this interaction. Interaction effects were significant in years 2009, 2012, 2013, 2014, and 2015 specifically, as these years represented both a significant change from the year prior, and significant differences between treatment and control groups. Figure 24 depicts estimated marginal means of folio densities (counts per acre) within treatment and control groups over time adjusted for all covariates.

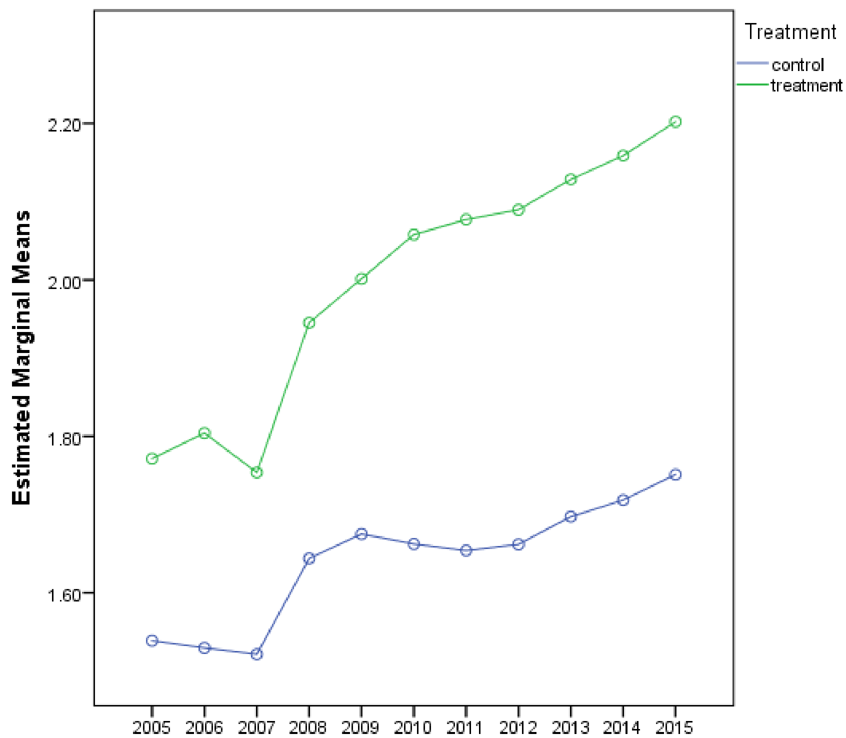


Figure 25: Estimated Marginal Means, Folio Densities

Table 11: ANOVA Source Table, Folio Densities, Within-Subjects

Source	*df*	*F*	*p*	$\eta^2_{partial}$
Time	1.99	2.05	.130	.01
Time x Treatment	1.99	6.74	.001	.02
Time x Median Household Income	1.99	0.31	.735	.00
Time x Per Capita Income	1.99	7.09	.001	.02
Time x Cars per Household	1.99	2.08	.126	.01
Time x Percent Houses Vacant	1.99	2.33	.098	.01
Time x Percent Houses Owner Occupied	1.99	0.19	.824	.00
Time x Cars per Owner Occupied Household	1.99	0.40	.667	.00
Time x Household Size	1.99	3.00	.050	.01
Time x How significant/important was value capture strategy to financial viability or project success?	1.99	0.61	.546	.00
Time x How important are public-private value creation strategies to the success of transit-influenced or transit-oriented development?	1.99	4.50	.011	.01
Time x How important are public-private value creation strategies to the success of transit infrastructure investments and projects?	1.99	1.07	.345	.00
Time x How important is value capture to the success of transit infrastructure investments and projects?	1.99	0.09	.916	.00
Time x Rent Burden >30%	1.99	0.99	.372	.00
Time x Parking Spaces	1.99	0.51	.602	.00
Time x Station Design	5.98	1.12	.348	.01
Time x Station Typology	11.96	1.36	.182	.02
Time x System	25.91	2.29	.000	.07
Time x Character	1.99	0.67	.510	.00
Error	833.08	-	-	-

Qualitative results

Planners and/or managers of the 12 of 14 subject transit agencies responding to the survey (instrument is included below as Appendix I) provided an opportunity to investigate their perspectives regarding various aspects of value capture, through four open-ended questions.

The first of these was: “How has the importance of value capture changed over time?” The consensus response was that as funding sources in general, and federal funding in particular, have become more difficult to secure, local (non-state) funding has become and will continue to be increasingly important. Value capture is a central component of local funding strategies and may become a determinant of success for future projects. The following comment was typical:

> In the early days of development … funding was 'plentiful' or at least less competitive and more available at the federal, state and local levels. Given the funding climate at all [three] levels now, there is significant pressure for local agencies and project sponsors to bring more funds to the table and [value capture] - at least as a concept - is rising to a position much higher on the list of possible sources. Financial responsibility is [now] much more at [the] local level.

The second of four questions asked of transit agency planners and managers was: "What do you perceive to be the greatest barriers to realizing transit-related value capture?" Responses to this question fell into three categories; 1) limited independent authority of transit agencies to undertake and impose value capture strategies and/or limited (state) statutory authorization of specific value capture tools; 2) political and/or public policy tension, particularly with respect to TIF, regarding "diversion" of tax revenues that could otherwise be expended on other (non-transit) projects; and 3) inadequacy of "business case" arguments that transit infrastructure investments are, in fact, producing the "surplus" value to be captured to offset that investment.

The third survey question asked of transit agency planners and managers was: "What lessons has your experience provided with respect to transit infrastructure related value creation and value capture?" Although there was some variation in perspective here, the dominant message was that education of policy makers, stakeholders, and the public at large with respect to the benefit and equity of value capture is a time-consuming effort requiring significant "front end" commitment of resources. Project-specific comments included the following:

> Making the business case to redirect funds from the municipal general fund remains a challenge. Growth in property taxes, as an example, is usually already embedded in the municipal budget and revenue growth curve (i.e. revenues are "spoken for") long before a transit department can try and make the case for value capture if it is not part of the project predevelopment strategy.

The question: "Do you have any suggestions or recommendations for implementing future transit-related value creation and/or value capture projects?" resulted in recommendations that included starting the process of engagement with prospective public and private sector partners very early in the pre-development process and incorporating value capture strategies (and revenue) in project pre-development financial planning.

All surveyed transit agencies articulated goals and responded to inquiries with responses consistent with a need to better understand conditions precedent to value creation and those factors contributing to variation in development success and value creation in proximity to transit stations. Transit planners and managers are increasingly interested in understanding the value creation process, particularly with a view towards facilitating greater and more productive third-party engagement, and engaging earlier and more affirmatively in value creation strategies.

Summary of findings

As hypothesized, differential rates of assessed value creation varied widely across transit systems and individual stations. Transit Areas of Influence (TAIs) in the top 20% of differential value creation experienced average annual growth rates 30.67% faster than that of control, whereas TAIs in the bottom quintile experienced negative average annual differential growth rates (1.25% less than those within control areas). Significantly positive differential value creation was concentrated within a small number of transit systems and within a relatively few stations along several of the lines studied.

Differential rates of assessed value creation are found to accrue disproportionately to improvements (and to folio density) rather than to land. In the aggregate, assessed improvement(s) values grew 4.35% faster in treatment areas than in control, whereas assessed land values grew only 3.28% faster within treatment areas. The extent to which treatment explained variation in differential value creation was approximately twice that for assessed improvement(s) value and that for assessed land value; approximately 2% compared to approximately 1%. Additionally, although the treatment-time interaction effects were significant over the entire period for assessed improvement values, the effect was not significant in any individual year for assessed land value.

Significant covariates included transit system (location), accounting for 19% of the differential rate of change in total assessed value per acre over time; per capita income (at the census block-level), accounting for an additional 3% of variation; station design, accounting 2% of variation; transit agency perceptions of public-private value creation strategies as important 1) to the success of transit infrastructure investments and projects, and 2) to the success of transit-influenced or transit-oriented development, accounted for an additional 1% of variation each. Significantly positive differential value creation occurred predominantly near at-grade stations.

Of numerous demographic covariates evaluated, only per capita income and vehicles per household were significant, predicting 4% and 2%, respectively, of differential rates of change over time (the interaction of covariate and time) between treatment and control groups.

Implications for literature

The findings that the extent of differential assessed value creation varies significantly from one market, transit line, or station to another is consistent with that variation on consumer's marginal willingness to pay for increased mobility, enhanced accessibility, and/or other related amenities such as those associated with TOD. Results of this study both underscore the extent of that variability and reveal variation in rates of value creation over a significant period of time. This study quantifies various aspects of differential value creation in terms of assessed valuation, the lingua franca of municipal and ad valorem tax revenue-based finance, rather than in terms of the more theoretical economic framework of consumers' marginal willingness to pay. Other implications with respect to academic literature are discussed below under opportunities for future research. These include the need for more complete understanding of 1) the economic, market, and sub-market factors that allow robust differential value creation in some places, but flat or negative outcomes in others; 2) factors, perhaps including institutional practices or constraints, result in value creation becoming (apparently) disproportionately assessed to values of improvements as opposed to land; and 3) forces that allowed rates of differential value creation to be so much greater within some markets (transit systems) than others over the same period of years.

CHAPTER 7: RESULTS (Panel Regression, uncropped overlapping treatment areas)

A second analysis was performed on the 200 of 229 station areas for which there were no missing annual assessed valuation data. Regression analysis was performed on panel data constructed based on a different research design premise than that underpinning the ANOVA analysis reported above. Each of the (502.66 acre) Transit Areas of Influence (treatment areas) within ½-mile of station area centroids was considered in its entirety, regardless of whether or not that treatment area encroached into and overlapped one or more adjoining Transit Areas of Influence. Whereas Thiessen polygons and a GIS union method were previously employed to eliminate overlapping treatment areas so as to avoid double counting of folio values within treatment areas (described in Research Methods and Design, Chapter 3 and within Appendix III), no such "cropping" of treatment areas was undertaken for this alternative (panel regression) analysis; this revised definition of treatment areas includes every folio within ½-mile of station centroids.

The following figure illustrates the overlapping ½-mile radius Transit Areas of Influence surrounding the Farmdale and Expo/La Brea stations on the La Brea Line in Los Angeles. The small dots represent centroids of all taxable folios within TAIs/treatment areas. Values for folios falling within both station area TAIs are included within treatment for each station.

Figure 25: Overlapping Transit Areas of Influence and Treatment Areas

Although this analysis considers a slightly different (reduced) dataset and was based on a different definition of treatment geographies, overall results were similar to those reported under ANOVA above. Aggregate total assessed value within treatment areas increased 146% over the11-years of measurement from 2005 through 2015, whereas that value within control areas increased only 82% over the period. Aggregate total assessed value per acre within treatment areas increased at an average annually compounded rate of 3.21% faster than that within control areas, or a total of 63% over the period.

Table 12: Differential Rates of Total Assessed Value Growth per Acre, by Station Quintile

	Total Assessed Value Growth From 2005 Through 2015			Average Annual (compounded) Rate of Total Assessed Value Growth		
	within treatment areas	within control areas	difference between treatment and control	within treatment areas	within control areas	difference between treatment and control
Quintile 1	**351%**	**72%**	**279%**	**16.25%**	**5.56%**	**10.69%**
Quintile 2	**186%**	**74%**	**111%**	**11.07%**	**5.72%**	**5.35%**
Quintile 3	**79%**	**54%**	**26%**	**6.02%**	**4.40%**	**1.62%**
Quintile 4	**71%**	**58%**	**13%**	**5.50%**	**4.67%**	**0.84%**
Quintile 5	**144%**	**159%**	**-15%**	**9.33%**	**10.00%**	**-0.67%**
Total	**146%**	**82%**	**63%**	**6.02%**	**4.40%**	**3.21%**

As in the previous analysis, however, differential rates of value increase were highly varied across stations. The aggregate differential rate of assessed value creation per acre within the "top" quintile of stations was more than twice that within the second quintile; and the rate was negative within the lowest quintile. As anticipated, differential rates of value creation were somewhat higher across many stations in this alternative analysis as a result of some high-value properties (office or condominium towers, for example) in proximity to station areas being captured within two or more treatment areas.

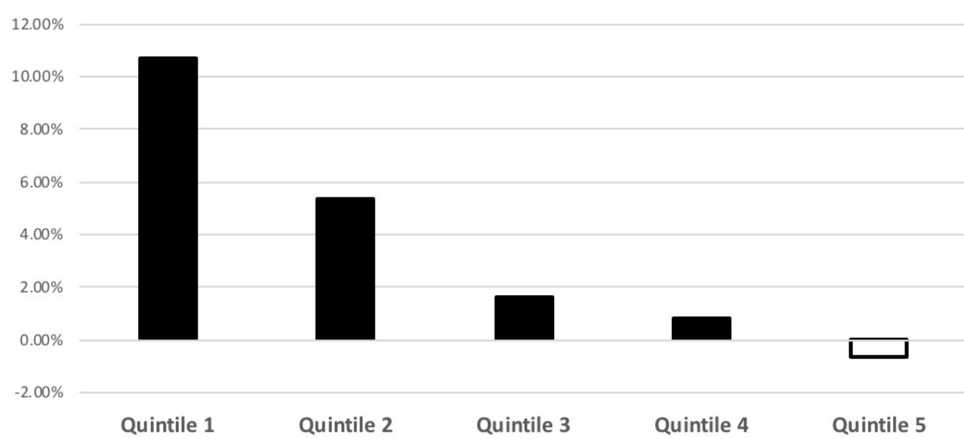


Figure 26: **Differences Between (Compounded) Annual Rates of AV Creation Within Treatment and Control Areas, by Quintile**

As in the analysis above, differential rates of assessed value creation per acre were also highly varied across transit systems. Differences between compounded annual rates of value creation within treatment and control areas ranged from -1.16% to 7.82% (3.21% average across all stations, regardless of system). Note however that differential rates of value creation were uncorrelated with absolute levels of assessed value per acre or value creation. Assessed values per acre, and year over year increases in some densely urban areas of Seattle, for example, were among the highest in the study. Yet differential rates of value creation within treatment areas grew at a slightly lower rate than in surrounding control areas where assessed values per acre grew at even higher rates.

Table 13: Differential Rates of Total Assessed Value Growth per Acre, by Transit System

	Total Assessed Value Growth From 2005 Through 2015			Average Annual (compounded) Rate of Total Assessed Value Growth		
	within treatment areas	within control areas	difference between treatment and control	within treatment areas	within control areas	difference between treatment and control
Dallas	265%	79%	186%	13.83%	6.01%	7.82%
Charlotte	146%	54%	92%	9.41%	4.41%	5.01%
Minneapolis	136%	57%	79%	8.96%	4.60%	4.36%
Denver	120%	54%	66%	8.22%	4.41%	3.81%
Salt Lake City	90%	50%	41%	6.65%	4.13%	2.52%
NJT Hudson-Bergen	289%	218%	71%	14.56%	12.28%	2.28%
Los Angeles	99%	69%	30%	7.12%	5.38%	1.74%
Portland	89%	69%	20%	6.57%	5.37%	1.20%
Houston	193%	164%	30%	11.37%	10.18%	1.18%
NJT River Line	65%	52%	14%	5.14%	4.24%	0.90%
San Diego	44%	33%	11%	3.69%	2.90%	0.79%
Norfolk	139%	128%	12%	9.12%	8.58%	0.54%
Seattle	192%	224%	-32%	11.32%	12.48%	-1.16%
Total	146%	82%	63%	9.40%	6.20%	3.21%

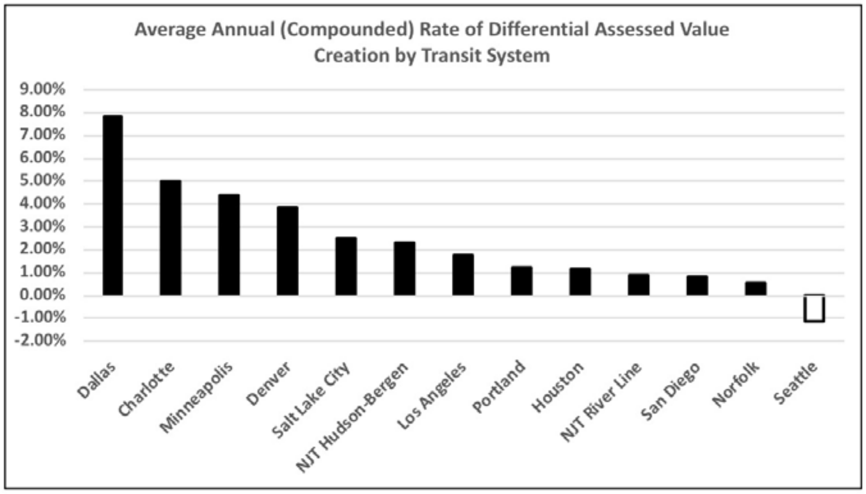


Figure 27: **Differences Between (Compounded) Annual Rates of AV Creation Within Treatment and Control Areas, by Transit System**

Rates of differential total assessed value per acre were highly varied within (along) specific transit lines as well as across all transit systems and stations. Results from the Blue Line in Charlotte, North Carolina are provided as illustrative example.

Table 14: Differential Rates of Total Assessed Value Growth/Acre by Charlotte Blue Line Station

	Total Assessed Value Growth From 2005 Through 2015			Average Annual (compounded) Rate of Total Assessed Value Growth		
	within treatment area	within control area	difference between treatment and control	within treatment area	within control area	difference between treatment and control
New Bern	280%	53%	227%	14.28%	4.34%	9.94%
Stonewall	299%	66%	232%	14.83%	5.23%	9.61%
7th Street	229%	71%	158%	12.64%	5.50%	7.14%
East/West Boulevard	187%	57%	130%	11.13%	4.61%	6.52%
Carson	127%	64%	63%	8.55%	5.09%	3.46%
Woodlawn	105%	52%	53%	7.44%	4.29%	3.15%
Bland Street	105%	59%	47%	7.46%	4.72%	2.73%
Scaleybark	43%	54%	-11%	3.65%	4.39%	-0.74%
Arrowood	31%	43%	-12%	2.74%	3.63%	-0.89%
Tyvola	30%	43%	-13%	2.63%	3.62%	-0.99%
Sharon Road West	6%	25%	-19%	0.56%	2.22%	-1.66%
Archdale	21%	55%	-34%	1.89%	4.45%	-2.56%
I-485/South Boulevard	-2%	35%	-37%	-0.21%	3.01%	-3.23%
Total	146%	54%	92%	9.41%	4.41%	5.01%

Differences between compounded annual rates of value creation within treatment and control areas within the 13-stations studied along the CATS Blue Line ranged from -3.23% to 9.94% (5.01% on average). Seven of the 13-station experienced positive differential rates of value creation per acre over the study period, while the other six experienced lower rates of value creation within treatment areas than within surrounding control areas.

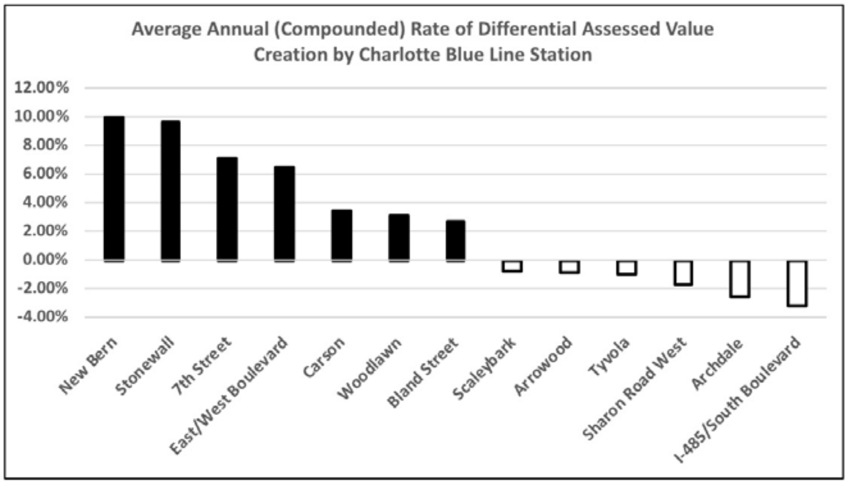


Figure 28: **Differences Between (Compounded) Annual Rates of AV Creation Within Treatment and Control Areas Along Charlotte's Blue Line by Transit System**

Highly varied outcomes resulted notwithstanding that similar levels of regulatory entitlement and infrastructure investment were provided within each station area and Transit Area of Influence. Transit-Oriented Development has been encouraged in all station areas, and similar development incentives have been provided. Charlotte's policy makers and planners within both the Charlotte-Mecklenburg Planning Department and the Charlotte Area Transit System (CATS) are sensitive to the extent of variation in market response to investment in Blue Line stations along the corridor and continue to explore opportunities for encouraging more growth and development near stations where market response has been modest and/or where there has been little or no development activity**.**

Panel Regression

Differential rates of total assessed value growth per acre, by station per year, were regressed on a variety of prospectively explanatory variables to estimate the extent to which they might be associated with differential rates of assessed value growth. Independent variables were comprised of transit system, station characteristics (design, typology, character), transit agency goals and objectives, value creation and value capture strategies, the relative importance to transit agencies of various objectives and outcomes, and a variety of demographic characteristics, all previously described. Given that many of the independent (prospectively explanatory) variables are time-invariant with respect to stations, random-effects panel regression was employed (A Kohler & A Kreuter, 2012). Practical experience, intuition, and results presented herein all suggest that differences across stations, lines, and transit systems (metropolitan markets) unaccounted for in these analyses, have influence on the rate of assessed value creation per acre. Consistent with ANOVA results reported above, very few (perhaps surprisingly few) of the prospective predictor variables were of statistical significance.

Prior to performing regression analyses, a paired t-test was performed to confirm there was a statistically significant mean difference between total assessed values per acre within treatment areas and those within control areas. As previously reported, mean total assessed value per acre was higher within treatment areas than within control areas. Mean total assessed value per acre within treatment areas, across all periods, was $734,893 (95% CI, $678,442 to $791,343), compared to $551,469 within control areas (95% CI, $529,857 to $573,082). There was a statistically significant mean difference of $183,423 per acre (95% CI, $137,343 to $229,503); $t(2199) = 7.8060$, $p < 0.0005$.

From 2005 through 2015, mean total assessed value per acre increased from $451,185 to $1,108,469 with treatment areas, and increased from $392,200 to $715,636 within control areas. The difference between mean total assessed value per acre within in treatment areas and that within control areas increased from $58,985 in 2005 to $392,833 in 2015.

A second paired t-test was performed to determine whether there was a statistically significant mean difference between annual growth rates (in total assessed values per acre) within treatment areas and those within control areas. As previously reported, growth rates were higher within treatment areas than within control areas in the aggregate. The mean annual growth rate within treatment areas was 10.95% (95% CI, 9.21% to 12.72%), compared to 6.91% within control areas (95% CI, 6.01% to 7.81%). There was a statistically significant mean difference of 4.04% per acre (95% CI, 2.52% to 5.57%); $t(1999) = 5.1997$, $p < 0.005$.

Differential rates of total assessed value growth per acre by station were regressed on time (year) to evaluate the extent to which any particular year (or all years) were significant predictors of variation in growth rates. As in all following models, assessed value per acre is differenced at the station level. The outcome of interest is the relative difference in the rate of change of assessed valuation per acre within treatment areas compared to that within control areas. For this reason, the regression constant is a material value rather than a nuisance parameter (as it might be in some social science models). In the following model, for example, the constant was significant, $p = 0.031$, and the coefficient was positive, reflecting a significant effect of treatment. Between 2005 and 2015, only 2008 was significant, $p = 0.033$. Differential rates of growth were also regressed on the years-in-service of stations (elapsed time since commencement of service), resulting in no statistical significance.

Table 15: Panel Regression Differential Rates Total Assessed Value Growth/Acre on Year (only)

Random-effects GLS regression						Number of obs =	2,000
Group variable: ID						Number of groups =	200
R-sq:						Obs per group:	
	within = 0.0000					min =	10
	between = 0.0000					avg =	10
	overall = 0.0047					max =	10
(Robust Standard. Error adjusted for 200 clusters in ID)						Wald chi2(9) =	17.18
corr(u_i, X) = 0 (assumed)						Prob > chi2 =	0.046

Differential AV Growth Rate		Coef.	R. Std. Err.	z	P>z	[95% Conf. Interval]	
YEAR							
	2007	0.0232687	0.0228922	1.02	0.309	-0.0215992	0.0681366
	2008	0.0421887	0.0198235	2.13	0.033	0.0033354	0.081042
	2009	-0.0180831	0.0156962	1.15	0.249	-0.0488472	0.0126809
	2010	0.0051497	0.0157996	0.33	0.744	-0.025817	0.0361163
	2011	0.0150214	0.0189829	0.79	0.429	-0.0221845	0.0522273
	2012	0.0672385	0.0638024	1.05	0.292	-0.057812	0.192289
	2013	0.025182	0.0250502	1.01	0.315	-0.0239156	0.0742795
	2014	-0.0074505	0.0125121	0.60	0.552	-0.0319737	0.0170727
	2015	0.028852	0.0183319	1.57	0.116	-0.0070779	0.0647819
_cons		0.0222981	0.0103068	2.16	0.031	0.0020971	0.0424991
sigma_u		0.07818137					
sigma_e		0.33883705					
rho		0.05054732	(fraction of variance due to u_i)				

Differential rates of total assessed value growth per acre by station were regressed (solely) on station design, station typology, and station character (all previously defined, and as reported through transit agency survey responses). Of these, significant variables included "At Grade" (Station Design, with a positive coefficient relative to "Underground" as base, p = 0.034, suggesting that greater differential value creation is realized where station are at-grade as opposed to being elevated or underground); and "Urban Neighborhood" (Typology, with a negative coefficient relative to "Campus/Other" as base, p = 0.001, suggesting that less differential value creation is realized where stations are located within urban neighborhoods than within campus or other settings). Significant care should be taken, and caution observed, however, before interpreting either statistical significance or the magnitude (or sign) of coefficients at face value, either in this model or those that follow. As discussed elsewhere, particularly within the Limitations chapter, these regression analyses undertaken in effort to explain observed variation in differential rates of value creation per acre (between treatment and control) appear to suffer from significant omitted or unobserved covariates (such as local market and submarket conditions) and confounding. As various station-specific and transit agency-specific characteristics we combined with demographic covariates, and subject to interaction with time, variables which were not significant become significant and vise versa. The magnitude as signs of coefficients changed as well. One suspects something like Simpson's Paradox where the association of an independent variable with the dependent outcome variable changes (either in significance, magnitude, or direction/sign) once other variables are controlled for. (Hernán, Clayton, & Keiding, 2011; Otte, 1985; Tu, Gunnell, & Gilthorpe, 2008)

Table 16: Panel Regression Differential Rates of Total Assessed Value Growth per Acre on Station Characteristics (only)

Random-effects GLS regression					Number of obs =	1,910
Group variable: ID					Number of groups =	191
R-sq:					Obs per group:	
within = 0.0000					min =	10
between = 0.0986					avg =	10
overall = 0.0143					max =	10
(Robust Standard. Error adjusted for 180 clusters in ID)					Wald chi2(9) =	71.14
corr(u_i, X) = 0 (assumed)					Prob > chi2 =	0
Differential AV Growth Rate	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
S_DESIGN						
Elevated	-0.0093027	0.014001	0.66	0.506	-0.0367441	0.0181387
At Grade	0.0313173	0.014806	2.12	0.034	0.0022981	0.0603364
Open Cut	-0.0301154	0.0256395	1.17	0.240	-0.080368	0.0201372
S_TYPOLOGY						
CBD	0.012918	0.0244813	0.53	0.598	-0.0350645	0.0609004
Urban Center	-0.0121984	0.0188336	0.65	0.517	-0.0491116	0.0247148
Urban Neighborhood	-0.0429905	0.0131666	3.27	0.001	-0.0687966	-0.0171844
Town Center Suburban	0.1002894	0.1079072	0.93	0.353	-0.1112049	0.3117837
Neighborhood Suburban	0.0015889	0.0251217	0.06	0.950	-0.0476488	0.0508265
S_CHARACTER						
Walk and Ride	0.0274400	0.0325725	0.84	0.400	-0.036401	0.0912809
_cons	0.0078890	0.0317317	0.25	0.804	-0.054304	0.070082
sigma_u	0.07320754					
sigma_e	0.34501818					
rho	0.04308262	(fraction of variance due to u_i)				

Differential rates of total assessed value growth per acre by station were regressed (solely) on transit agencies' primary objectives driving planning/development of subject transit line and station areas (as previously defined, and as reported through transit agency survey responses); none of which were significant.

Table 17: Panel Regression Differential Rates of Total Assessed Value Growth per Acre on Reported Transit Planning and Development Objectives (only)

Random-effects GLS regression					Number of obs =	2,000
Group variable: ID					Number of groups =	200
R-sq:					Obs per group:	
within = 0.0000					min =	10
between = 0.3446					avg =	10
overall = 0.0499					max =	10
					Wald chi2(7) =	5.98
(Robust Standard. Error adjusted for 200 clusters in ID)						
corr(u_i, X) = 0 (assumed)					Prob > chi2 =	0.5417
Differential AV Growth Rate	Coef.	R. Std. Err.	z	P>z	[95% Conf. Interval]	
GOAL_FUTURE	-0.017544	0.0119645	1.47	0.143	-0.0409939	0.0059059
GOAL_RIDERSHIP	-0.0041901	0.0134045	0.31	0.755	-0.0304625	0.0220823
GOAL_CONGESTION	0.0034968	0.0100753	0.35	0.729	-0.0162504	0.023244
GOAL_ED	0.0128578	0.0167104	0.77	0.442	-0.0198941	0.0456097
GOAL_PLANNING	0.0027029	0.0155365	0.17	0.862	-0.0277482	0.0331539
GOAL_POLITICAL	0.0059253	0.0126479	0.47	0.639	-0.0188641	0.0307148
GOAL_COMMERCIAL	0.7744867	0.5755966	1.35	0.178	-0.353662	1.902635
_cons	0.0324975	0.0167036	1.95	0.052	-0.0002409	0.065236
sigma_u	0.0215753					
sigma_e	0.338917					
rho	0.0040362	(fraction of variance due to u_i)				

Differential rates of total assessed value growth per acre by station were regressed (solely) on value creation strategies employed by transit agencies in connection with transit line/station planning and development (as previously defined, and as reported through transit agency survey responses); none of which were significant.

Table 18: Panel Regression Differential Rates of Total Assessed Value Growth per Acre on Reported Transit Agency Value Creation Initiatives (only)

Random-effects GLS regression						Number of obs =	2,000
Group variable: ID						Number of groups =	200
R-sq:						Obs per group:	
	within = 0.0000					min =	10
	between = 0.0358					avg =	10
	overall = 0.0052					max =	10
(Robust Standard. Error adjusted for 200 clusters in ID)						Wald chi2(4) =	5.98
corr(u_i, X) = 0 (assumed)						Prob > chi2 =	0.2009
Differential AV Growth Rate	Coef.	R. Std. Err.	z	P>z	[95% Conf. Interval]		
VAL_NONE	0.0143	0.0448356	0.32	0.750	-0.0735763	0.1021762	
VAL_ENTITLEMENTS	0.0598106	0.0579894	1.03	0.302	-0.0538465	0.1734677	
VAL_MUNINF	-0.0309733	0.0174044	1.78	0.075	-0.0650853	0.0031387	
VAL_ASSEMBLAGE	0.0289171	0.052534	0.55	0.582	-0.0740477	0.131882	
_cons	0.0122044	0.0430033	0.28	0.777	-0.0720806	0.0964894	
sigma_u	0.07632214						
sigma_e	0.338917						
rho	0.0482648	(fraction of variance due to u_i)					

Differential rates of total assessed value growth per acre by station were regressed (solely) on transit agencies' perceived significance/importance of various value creation and capture strategies to financial viability or project success, TOD development success, and the success of transportation infrastructure investments (as reported through transit agency survey responses). Again, the outcome of interest is the relative difference in the rate of change of assessed valuation per acre within treatment areas compared to that within control areas. In this model, the regression constant was significant, p = 0.009, and the coefficient was positive, reflecting a significant effect of treatment. None of independent covariates, however, were statistically significant predictors of differential rates of value creation.

Table 19: Panel Regression Differential Rates of Total Assessed Value Growth per Acre on Reported Transit Agency Perceptions of the Importance of Various Value Creation and Capture Strategies to Financial Viability or Project Success (only)

Random-effects GLS regression				Number of obs =		1,810
Group variable: ID				Number of groups =		181
R-sq:				Obs per group:		
	within = 0.0000			min =		10
	between = 0.0700			avg =		10
	overall = 0.0077			max =		10
(Robust Standard. Error adjusted for 181clusters in ID)				Wald chi2(11) =		40.91
corr(u_i, X) = 0 (assumed)				Prob > chi2 =		0

Differential AV Growth Rate	Coef.	R. Std. Err.	z	P>z	[95% Conf. Interval]	
VC_FINIMPORTANCE						
Slightly Important	0.0205275	0.0280356	0.73	0.464	-0.0344213	0.0754763
Moderately Important	-0.0116708	0.0164685	-0.71	0.479	-0.0439484	0.0206068
Significantly Important	-0.0217834	0.018231	-1.19	0.232	-0.0575156	0.0139487
Very Important	0.0123983	0.0265667	0.47	0.641	-0.0396714	0.0644681
PPE_TOD_IMPORTANCE						
Slightly Important	0.0272859	0.0193435	1.41	0.158	-0.0106267	0.0651984
Moderately Important	-0.0336873	0.0192787	-1.75	0.081	-0.0714728	0.0040982
Significantly Important	0.0105012	0.0165517	0.63	0.526	-0.0219396	0.042942
Very Important	-0.0130826	0.0157669	-0.83	0.407	-0.0439851	0.0178199
PPE_TRANS_IMPORTANCE						
Moderately Important	0.0172637	0.0147567	1.17	0.242	-0.011659	0.0461864
Significantly Important	-0.0132616	0.0194653	-0.68	0.496	-0.051413	0.0248897
_cons	0.0265222	0.010145	2.61	0.009	0.0066383	0.0464061
sigma_u	0.018191					
sigma_e	0.1755852					
rho	0.0106194	(fraction of variance due to u_i)				

Differential rates of total assessed value growth per acre by station were regressed (solely) on value capture strategies employed in connection with transit line/station planning and development (joint development, negotiated exactions, special assessments, naming rights, or land value taxation, as reported through transit agency survey responses); none of which were significant. Once again, however, the regression constant was significant, p = 0.009, and the coefficient was positive, reflecting a significant effect of treatment itself.

Table 20: Panel Regression Differential Rates of Total Assessed Value Growth per Acre on Reported Employment of Various Value Capture Strategies (only)

Random-effects GLS regression					Number of obs =	2,000
Group variable: ID					Number of groups =	200
R-sq:					Obs per group:	
within = 0.0000					min =	10
between = 0.0472					avg =	10
overall = 0.0068					max =	10
(Robust Standard. Error adjusted for 200 clusters in ID)					Wald chi2(4) =	5.66
corr(u_i, X) = 0 (assumed)					Prob > chi2 =	0.2264
Differential AV Growth Rate	Coef.	R. Std. Err.	z	P>z	[95% Conf. Interval]	
VC_JOINTDEVELOPMENT	-0.0492563	0.040859	-1.21	0.228	-0.1293384	0.0308258
VC_EXACTIONS	0.0118525	0.0256562	0.46	0.644	-0.0384327	0.0621377
VC_SADS	-0.0526231	0.0349949	-1.50	0.133	-0.1212119	0.0159656
VC_NONE	-0.0750624	0.0477282	-1.57	0.116	-0.1686078	0.0184831
_cons	0.1021178	0.0474861	2.15	0.032	0.0090467	0.1951889
sigma_u	0.0749699					
sigma_e	0.338917					
rho	0.0466488	(fraction of variance due to u_i)				

The full random-effects panel regression model was specified employing all prospective explanatory variable not dropped from regression due to collinearity. The time specification included the 11 years from 2005 through 2015. Independent variables included transit system (S_SYSTEM), years in service, station design (as indicated in following table, with "underground" specified as base condition), station typology (as indicated, with "campus/other" specified as base condition), station character (with "park and ride" specified as base condition), transit agencies' primary objectives driving planning/development of subject transit line and station areas (as previously defined), value creation strategies employed by transit agencies in connection with transit line/station planning and development (as previously defined), specific value capture strategies employed, transit agencies' perceived significance/importance of value creation and capture strategies to financial viability or project success, TOD development success, and the success of transportation infrastructure investments, and various demographic characteristics (previously described).

Statistically significant independent variables with the full model included "At Grade Station Design" (positive coefficient relative to Underground Station Design, p = 0.019), "Urban Neighborhood Typology" (negative coefficient relative to Campus/Other, p = 0.001), "Serving anticipated residents and workers drawn to new development near transit stations" as a principal transit agency planning/development goal (negative coefficient, p = 0.000, all other transit agency goals were dropped due to collinearity or lack of response), and providing "land use and zoning entitlements" as enticement for development as part of a value creation strategy (negative coefficient, p = 0.015). Of demographic covariates including median household income, rent burden, home ownership rate, and cars per household, only "rent burden" (those spending 30 percent or more of income on housing costs) was significant with a negative coefficient for differential value creation, p = 0.016.

Given the limited extent of statistical significance across various station and transit agency characteristics, collinearity between a number of variables (such as value creation initiatives with other factors), the extent to which other prospectively explanatory values appear to absorb the effect of transit agency (S_SYSTEM/metropolitan market), for example, significant cofounding between independent variables is assumed.

Table 21: Full Regression Model: Panel Regression Differential Rates of Total Assessed Value Growth per Acre on All (non-dropped) Independent Variables

Random-effects GLS regression					Number of obs =	1,800
Group variable: ID					Number of groups =	180
R-sq:					Obs per group:	
within = 0.0000					min =	10
between = 0.3966					avg =	10
overall = 0.0435					max =	10
(Robust Standard. Error adjusted for 180 clusters in ID)					Wald chi2(29) =	7914.93
corr(u_i, X) = 0 (assumed)					Prob > chi2 =	0

Differential AV Growth Rate	Coef.	R. Std. Err.	z	P>z	[95% Conf. Interval]	
S_SYSTEM	-0.0132336	0.0195175	0.68	0.498	-0.0514872	0.02502
YRS_in_SERVICE	0.0004978	0.0011325	0.44	0.660	-0.0017219	0.0027174
S_DESIGN						
Elevated	0.0166496	0.019643	0.85	0.397	-0.0218500	0.0551492
At Grade	0.0407558	0.0173783	2.35	0.019	0.0066949	0.0748167
Open Cut	0.0364269	0.0208949	1.74	0.081	-0.0045264	0.0773801
S_TYPOLOGY						
CBD	0.0159837	0.0174052	0.92	0.358	-0.0181299	0.0500973
Urban Center	-0.0120496	0.0202611	0.59	0.552	-0.0517606	0.0276614
Urban Neighborhood	-0.0420198	0.0130249	3.23	0.001	-0.0675481	-0.0164915
Town Center Suburban	0.0199475	0.0235873	0.85	0.398	-0.0262827	0.0661778
Neighborhood Suburban	-0.0280736	0.0178526	1.57	0.116	-0.0630641	0.0069169
S_CHARACTER						
Walk and Ride	-0.0173152	0.0105129	1.65	0.100	-0.0379202	0.0032897
GOAL_FUTURE	-0.1179973	0.0190679	6.19	0.000	-0.1553696	-0.0806249
VAL_ENTITLEMENTS	-0.1260862	0.051654	2.44	0.015	-0.2273262	-0.0248461
VAL_MUNINF	0.1193558	0.0816366	1.46	0.144	-0.0406489	0.2793606
VAL_ASSEMBLAGE	-0.0203555	0.1458568	0.14	0.889	-0.3062297	0.2655186
VC_JOINTDEVELOPMENT	0.118820	0.0927804	1.28	0.200	-0.3006662	0.0630262
VC_EXACTIONS	-0.1528622	0.2521507	0.61	0.544	-0.6470685	0.3413441
VC_NONE	-0.2431135	0.2122557	1.15	0.252	-0.6591270	0.1728999
VC_FINIMPORTANCE						
Slightly Important	-0.0411586	0.0690889	0.60	0.551	-0.1765703	0.0942531
Very Important	0.0202972	0.0924685	0.22	0.826	-0.1609378	0.2015323
PPE_TOD_IMPORTANCE						
Slightly Important	0.1625867	0.1225053	1.33	0.184	-0.0775194	0.4026927
Moderately Important	0.0580919	0.1063065	0.55	0.585	-0.1502650	0.2664488
Significantly Important	0.0261547	0.0611554	0.43	0.669	-0.0937077	0.1460172
Very Important	-0.0298587	0.1165691	0.26	0.798	-0.2583299	0.1986126
MHHI	0.0000001	0.0000002	0.39	0.693	-0.0000004	0.0000006
RENT_30	-0.0805794	0.0335595	2.40	0.016	-0.1463548	-0.0148039
PCT_OWN	-0.003384	0.0392316	0.09	0.931	-0.0802766	0.0735085
CARS_HH	-0.0440075	0.024016	1.83	0.067	-0.0910781	0.003063
_cons	0.4790922	0.3501229	1.37	0.171	-0.2071362	1.165321
sigma_u	0.00					
sigma_e	0.1760267					
rho	0.00	(fraction of variance due to u_i)				

CHAPTER 8: LIMITATIONS

Real estate is comprised of highly heterogeneous bundles of goods rendered unique by location. Real estate markets and submarkets are non-uniform, complex, and subject to significant fluctuation across time and space. Real estate markets are cyclical, but not coincident across classes of real property. This study's results suggest that market forces defined and influenced by factors outside the scope of those considered herein are responsible for greater fluctuation in differential value creation than that explained by modeled variables. Not the least of these may have been the overarching impacts and market distortions imposed by the Great Recession during the period of study. Market responses to stimuli such as transit infrastructure investment are complex and vary across time and from place to place. Some of the many potential limitations affecting both generalizability and validity of this study are as follow.

Non-random determination of transit line corridors and alignments, station locations and design, and institutional factors

A truly experimental research design requires random assignment of treatment to units of analysis. A concern with this quasi-experimental design is that assignment to treatment (e.g. design, entitlement, funding, and development of the transit corridors and location-specific stations) is entirely nonrandom. These decisions and outcomes result from political processes, economic, financial, market and engineering considerations and constraints, all of which are non-random.

Data quality

The quantitative analysis reflected herein incorporates three distinct datasets. These include 1) assessed valuation data comprising annual folio counts, assessed value of land, assessed value of improvements, and total assessed value, all expressed per acre within treatment and control areas from 2005 through 2015; 2) station-specific descriptive and quantitative data derived from surveys sent to senior transit system planners and managers; and 3) annual American Community Survey demographic data from 2010. Issues related to each of these datasets contributing to potential concerns regarding bias and/or validity are addressed as follows. The most significant of these concern the assessed valuation data itself, and the way in which it has been organized and compiled.

Tax assessment and methodology

Assessed valuation data can be considered "murky," particularly as reflections of market value in real time. There are several reasons for such concerns. Local governments assess the value of real and intangible property as the basis for the levy of taxes on which they depend for revenue. Tax assessors consider comparable sales and other data to estimate market value as the basis for assigning folio-specific assessed values for tax purposes. Regardless of how dynamic (or volatile) underlying real estate markets may be, assessed values are updated only annually, usually as of the first of January. Actual reevaluation and appraisal of individual properties may only occur at intervals of four to eight years or longer. Therefore, assessed values are not extremely sensitive or responsive to changes in underlying market value in real time. Assessed values lag market values both in expanding and contracting markets. Matters are complicated further by the fact that assessed values are influenced by political and policy considerations which may discount market values and/or attempt to moderate the effects of market volatility.

Market value is itself essentially unobservable in the aggregate. (Clapp, 1990) Market value is observed only for the relatively small number of properties (folios) that change hands in arm's length transactions each year. Assessed values may fail to reflect accurate market values in the short term but tend toward (correct to) market values over longer-term periods. Research suggests that "[assessed value] and [repeat sales] methods are substantially similar over a seven-year period. But [that] the repeat sales] method is inefficient because it uses a relatively small subset of the data." (Clapp & Giaccotto, 1992) The same study suggest that even rich repeat sales dataset remain inefficient in predicting aggregate value.

Greater understanding of the nature and extent of variation in assessment methodology and policy from one tax jurisdiction to another, and the degree to which aggregate assessed value may vary from aggregate market value within any given geography would provide additional nuance to these finding as well as having implication for practice. The extent to which rising assessed values may lag rising market values, for example, may represent opportunity in the nature of low hanging fruit with respect to value capture objectives.

Assessed valuation as a measure of value

Although assessed valuation is based on underlying market value, it is an imperfect, and frequently lagged reflection/indication of current market value. The deficiencies of assessed valuation as proxy for market value, particularly in real time, are mitigated by two considerations in the context of this study.

This analysis is motivated in part by considerations related to the potential for value capture techniques to provide an important source of funding for transit infrastructure projects. Several of the mechanisms and strategies through which some portion of transit infrastructure-induced value creation might be taxed for such purposes are dependent on assessed valuation either directly or indirectly. Tax increment financing (TIF) is an example. In many applications related to consideration of value creation and/or value capture, particularly from the perspective of state or local government, assessed valuation may be the most appropriate measure.

A second mitigating factor is that this study considers neither absolute market nor assessed values but differential rates of change in assessed value over time. The somewhat murky disconnect between assessed values and coincident market values is only problematic for these purposes if market and assessed valuations continue to diverge over time. Some researchers conclude that such concerns regarding the reliability of [assessment] data on property valuations in terms of variance between taxable and actual market value is effectively controlled through the very large number of folios (properties) examined (Weinstein et al., 2002).

Ultimately, assessed value fulfills the requirements necessary for value-representative statistical analysis: “six criteria which need to be satisfied from a statistical viewpoint: regular availability, representativeness, homogenous comparability, unbroken and unchanging description, length of series and data frequency” (Case & Wachter, 2005).

An observation regarding reassessment methodology

An additional factor contributing to the lumpiness of assessed valuation as a measure of market value at any one moment in time is the spasmodic and non-uniform nature of value reassessment. Approximately 4.5% of residential properties changed hands in 2015, the last year of data availability in this study (Realtors, 2017). This means that when and where property values are reassessed for tax purposes only when there are transactions, such reassessment affects only a small proportion of total real property inventory. Complicating this fact is that in many jurisdictions, such as those in California, conveyance of a partial interest in real estate (say, 50%) results in reappraisal of only that portion of the property conveyed, leaving the appraised value of the un-conveyed portion intact. Wholesale market-wide reassessment often occurs only every two to five years, and can occur as infrequently as every ten years in some cases. Once again, although appraised value will follow market value over long periods of time, aggregate assessed value and real-time market value will be non-uniform at any moment in time.

Structural bias in data aggregation and reporting

CoreLogic has been accumulating and reporting assessed valuation data at the individual parcel-/folio-level for 30-years. Due to limited market demand for historical data and the cost of maintaining databases comprised of many millions of individual folio records, CoreLogic chooses to maintain records only for the “current year” (2015 at the time this study was undertaken in 2016) and the 10-years prior to the “current year” (2005 through 2014 in this case). Variables capturing various aspects of assessed value records in prior years are associated with “current year” folio numbers. Historical records are maintained and reported only for folio numbers extant in the “current year” (2015). This data structure presents cause for concern both when historical folios (parcels) are subdivided into smaller parcels (or units) with multiple individual folio numbers and when multiple parcels are assembled into a single parcel within a single folio number. In either case, if consistency of folio number designation is not maintained by tax assessors over time, the available data structure may be biased toward higher aggregate assessed value within discrete geographical boundaries over time. Analysis of sample data within various jurisdiction suggests that this may not be a material problem, but it is one that must be disclosed. In general, folio numbers appear to be very stable over time.

Missing data

A potential source of bias results from the fact that across the 21 transit systems under consideration, specific stations were eliminated from analysis. These included 1) stations that predominantly served only a single institutional or commercial use such as a government complex, museum, campus, entertainment venue, or shopping mall; 2) stations that were significantly multimodal (beyond LRT and bus service), including heavy rail or commuter rail service, ferry service, etc.; and 3) where there were significant numbers of missing values under primary dependent variables. Stations eliminated from analysis for one or more of these reasons are identified in APPENDIX II

Measurement and reporting error

A potential source of bias within the assessed valuation data may be referred to broadly as measurement and reporting error. Between treatment and control observations, approximately 17-million individual observations of total assessed value and assessed value of land and improvements were recorded. Among these there were clear and obvious examples of erroneous values. CoreLogic collects and aggregates assessed valuation data from the many individual tax jurisdictions and through various mechanical means. Erroneous values may have been reported or recorded by the tax assessor, during data collection or consolidation, or somewhere in the process of aggregating data in CoreLogic's uniform data format. In many jurisdiction-specific data series, the same value, for total assessed value, for example, was reported under two or more alternative headings. Values aggregated at the station-and transit line- level for indication of obvious outliers. Specific variables reflecting values for total assessed value and assessed value of land and improvements were selected based on minimization of outliers and missing data. In all cases, the same variables were employed in both treatment and control. Outlying data values were not managed, however, at the level of the 51-million individual data points.

Transit Areas of Influence, treatment, control, and buffer area definitions.

To minimize the extent of treatment confounding control, and to minimize the extent to which particular folios (large land parcels) might overlap treatment and control areas, treatment and control areas are separated by a ½-mile buffer (illustrated in Figures 8 and 9 above). In addition to the buffers surrounding treatment areas, a buffer of ½-mile from the centerline of subject LRT lines is excluded from control areas. Rationale for elimination of folios within the ½-mile buffer area surrounding stations is that (notwithstanding APTA definition of primary catchment areas within TAIs), any treatment effect of proximity to transit stations including the benefits of mobility and accessibility being capitalized into real estate and reflected through market prices and assessed valuation, does not and would not end abruptly at the ½-mile radius. One practical effect of this is that comparing rates of change between control areas (at greater distance from stations) and those areas most impacted/benefited by proximity to stations is likely to overstate any aggregate treatment effect. On the other hand, this study is likely to underestimate aggregate differential value creation in that to the extent there is a positive (value-creating) treatment effect, it would likely extend beyond the arbitrary ½-mile radius.

Rationale for elimination of folios within the ½-mile buffer along rail line corridors outside of TAIs is that proximity to LRT lines and rail traffic may have a negative effect on the value of property not proximate to stations (within treatment areas). Folios within these buffer areas are eliminated to avoid overstatement of any prospectively positive treatment affect.

External validity

This analysis addresses external validity (limited to that within the continental United States) by studying and comparing differential value creation trends along 21 transit lines within 14 transit systems geographically dispersed across the United States and located within significantly heterogeneous metropolitan markets. Transit line selection is limited, however, by data availability in the 11-year period of 2005 through 2015, and those systems with new service development within a timeframe relevant for study given available assessed valuation data. The period under consideration reflects market conditions and other constraints and impacts specific to that time period. Beyond this general concern is the fact that the period of analysis spans the Great Recession and the many, perhaps confounding, impacts of the financial crisis and its aftermath. There is reason to believe that markets were working inefficiently in some cases and not at all in others during this period.

A longitudinal analysis extending many more years, both prior and subsequent to treatment, would be more robust. An earlier (prospective) design of this study would have included 30-years of observations (and more observable station areas as a result). Data prior to 2005 were simply not available, however, limiting both the robustness of the longitudinal difference-in-differences comparison and the number of station areas under consideration.

Serial correlation

Another concern related to the limited longitudinal data series, and the fact that we cannot observe pre-treatment values either within treatment or control areas for all cases, is that of serial correlation of outcomes and resulting inconsistency of standard errors. Stations along many lines are very close to each other (TAIs overlap in many cases). A result of which is that value creation in one is likely to affect that in proximate stations in some cases (Hubert, Golledge, & Costanzo, 1981). A 2002 paper by Bertrand, et. al., found that:

> Most papers that employ Differences-in-Differences estimation (DD) use many years of data and focus on serially correlated outcomes but ignore that the resulting standard errors are inconsistent. … These conventional DD standard errors severely understate the standard deviation of the estimators. … Two corrections based on asymptotic approximation of the variance-covariance matrix work well for moderate numbers of states and one correction that collapses the time series information into a "pre"- and "post"-period and explicitly takes into account the effective sample size works well even for small numbers of states.

Unfortunately, we do not have a very long longitudinal series and cannot observe "pre"- and "post"-periods in all cases.

Selection bias

This is a quasi-experimental study in the sense that repeated observations are made over an 11-year period in both treatment and control groups (areas); treatment being comprised of proximate LRT service delivered at/through newly-developed stations in specific locations. The difference-in-differences analysis is a comparison between treatment areas (TAIs within ½ mile of station centroid locations) and control areas (between 1-mile and 2-miles from station centroids) prospectively less-impacted by new transit accessibility and utility. Definition of treatment areas as those within a ½-mile radius of station centroids is motivated by a desire for consistency with literature defining TOD areas of greatest impact, dimensions employed in numerous other studies, and the Primary Catchment Area defined by APTA (APTA, 2009).

A truly experimental research design requires random assignment of treatment. A concern with this quasi-experimental design is that assignment to treatment (e.g. design, entitlement, funding, and development of the transit corridors and location-specific stations) is entirely nonrandom.

Treatment confounding control, interference, buffer effects

Selection of control geographies as defined herein is motivated in part by desire that results be intuitive: How did value creation in immediate proximity to LRT stations (within ½ mile) vary over time compared to areas in effectively the same location but further from stations (between 1-mile and 2-miles from transit stations) over the same period of time? One limitation of this approach is that value effects of the transit station treatment do not end abruptly ½-mile from station centroids. APTA defines TAIs as comprised of Core Station Areas (within ¼ mile radius), Primary Catchment Areas (½ mile radius, the area defined as treatment within this study), and Secondary Catchment area (within 2-miles; for semirapid transit). APTA also defines a Secondary Catchment Area of that within 5-miles for regional transit (APTA, 2009). The fact that value impacts of transit accessibility and related amenities may extend beyond ½ mile and include that area within a 2-mile radius of transit stations, encompassing that area defined herein as control, means that treatment effects may be understated in the difference-in-differences comparison.

Treatment and control areas are not only both affected to some degree by the LRT treatment as herein defined, but also by national, regional, and local markets and submarkets as well as many other environmental factors and characteristics affecting value creation, including those associated with transit accessibility (Gakenheimer et al., 2011). It is possible that market forces may affect treatment and control areas differently (even setting aside differential market responses to treatment), interfering with apparent results (Cervero & Landis, 1997).

Defining either treatment or control geographies differently would result in different mathematical results as a result of comparison groups comprised of different folios. So too does the definition of buffer areas affect results (buffer areas being those excluded both from treatment and control areas). To minimize the extent of treatment confounding control addressed above, and to minimize the extent to which particular folios (large land parcels) might overlap treatment and control areas, these were separated by a ½-mile buffer as illustrated in figures above. Importantly, this dimension is almost entirely arbitrary. Although much of the literature addressing TOD or otherwise transit-influenced development refers to this ½-mile dimension, and although the APTA definitions of TAIs make a distinction at ½-mile; the area defined by the next ½-mile radius could have been included in the area defined as treatment (i.e. treatment area could have been defined as that within 1-mile of station centroids). Conversely, the ½-mile buffer area could have been included in control (i.e. control areas could have been defined as those between ½-mile and 2-miles of station centroids). Further, buffer areas could have been eliminated altogether, or set to any larger dimension. In any event, the all but arbitrary definition of buffer area as that between ½-mile and 1-mile of station centroids will have influenced mathematical results.

In addition to the buffer established around treatment areas, a buffer of ½-mile from the centerline of subject LRT lines (outside of treatment areas) was excluded from control areas. The rationale for this is that proximity to LRT lines and rail traffic may have a negative effect on land and/or improvement values when properties are not near stations (within treatment areas).

Even within station areas, “without [adequate] attention to design, LRT stations may impose negative externalities on nearby properties, with a resulting decline in house values” (Al-Mosaind et al., 1993) Folios within these buffer areas were eliminated to avoid overstatement of any apparently positive treatment affect. In the event that proximity to light rail lines more than ½-mile from station areas has a positive value effect, however, an impact of eliminating these buffer areas from control could be to overstate treatment effect inadvertently.

Spatial autocorrelation

Data may be spatially autocorrelated when specific geographic or other features (such as market, sub-market, or demographic characteristics) are clustered together or near each other in physical space. The fact that the values associated with such spatially autocorrelated characteristics are (also, therefore) clustered and not independent. No effort has been made to identify or quantify the extent of the temporal autocorrelation certain to exist in these data. The non-independence of the values of these clustered data may affect the validity and/or generalizability of conclusions.

Temporal autocorrelation

The assessed valuation data relevant to this study are also temporally autocorrelated. Not only are values for specific folios linked to each other year over year, all are subject to effects of aggregate and macro market movements. Impacts and (obvious) effects of the Great Recession are particularly noteworthy as previously discussed. When specific values, characteristics, or other features (such as market, sub-market, or demographic characteristics) are clustered together or linked to each other over time, data are not entirely independent. The non-independence of the values of these clustered data may affect the validity and/or generalizability of conclusions.

Other confounding, and unobserved variables not included in model

Neither the statistically significant ANOVA results nor the regression coefficients can be interpreted as causal if the differential rates of assessed value creation per acre can be attributed to causes additional and/or alternative to proximity to light rail transit stations. alternate mechanism. Given that there are numerous market, sub-market, and locational characteristics (further confounding the matter of non-random assignment of station locations) no strictly accounted for in this study, no explicit interpretation of causal effect is presented.

Substitution effects

Residential properties, in particular, comprise a complex and highly heterogeneous bundle of goods. The very purpose of hedonic price models, for example, is to disaggregate consumers' willingness to pay for various individual aspects of complex bundles of goods so as to estimate the relative value of each. As the market price of any particular component within the overall bundle (such as location), or the price of the entire bundle of goods, increases, consumers are likely to substitute less costly goods (or components of goods) so as to achieve the same or similar level of satisfaction and utility subject to income and other constraints (Alonso, 1964). In considering absolute, incremental, or differential value creation, we do not know to what extent apparent (even differential) value creation within proximity to transit stations is realized at the cost of displaced value creation elsewhere within the same metropolitan market. This may not be of practical concern for financiers concerned with the effectiveness of various value capture strategies but may be of concern to policy makers considering the economic effectiveness of infrastructure investment alternatives. To the extent markets and submarkets within metropolitan areas are interconnected and linked, value creation in one location may come at the cost of value creation in another. (Cervero, 1995) To the extent markets are linked, control areas may be violating the stable unit treatment value assumption (SUTVA). (Winship & Morgan, 1999)

Treatment may be contaminating control areas in this case, in which case estimated impacts will be biased.

Conversely, where development and value creation appear not to have materialized in proximity to transit stations (nor to an extent sufficient to result in positive differential value creation), this does not necessarily mean that there was no value creation inducement. Other market factors and regulatory factors may displace would-be development and value creation to other locations where consumers are substituting one bundle of goods for another.

CHAPTER 9: CONCLUSIONS AND OBERVATIONS

Assessed value creation

Differential assessed value creation associated with proximity to LRT systems (the principal inquiry of this study) is highly varied and influenced by a wide variety of factors many of which were beyond the scope of these analyses. These conclusions were confirmed by complementary (ANOVA and panel regression) analyses based on similar subsets of the total assessed value data base, and alternative definitions of treatment area. In both cases, differential rates of total assessed value creation were highly varied, and a rich list of covariates describing station-specific and transit agency characteristics did little to explain that variation. As various permutation of ANOVA and regression models were considered and evaluated, it became clear that independent variables' influence on the dependent variable (differential rate of change) were weak and highly dependent on model specification.

Consistent with Simpson's paradox, modification of model specification resulted in changes to statistical significance and magnitude (and sign) of coefficients. These results provoke more questions regarding the causes of variation in differential rates station-specific light rail transit infrastructure induced value creation than they answer.

In the aggregate, "treatment" (proximity to stations) was highly statistically significant across the 229 stations in this study but accounted for only 2% of the variation in differential rates of change in total assessed value over the 11-year timeframe observed. Virtually all of this aggregate treatment effect results from stations within the top 20% of stations ordered by differential rate of value creation. The top quintile of stations realized an average annual differential rate of total assessed value creation of 30.67%, whereas stations within the bottom quintile experienced an average annual <u>decrease</u> of 1.25%. Differential value creation with the 2nd, 3rd, and 4th quintiles was essentially "flat," as depicted in Figure 25.

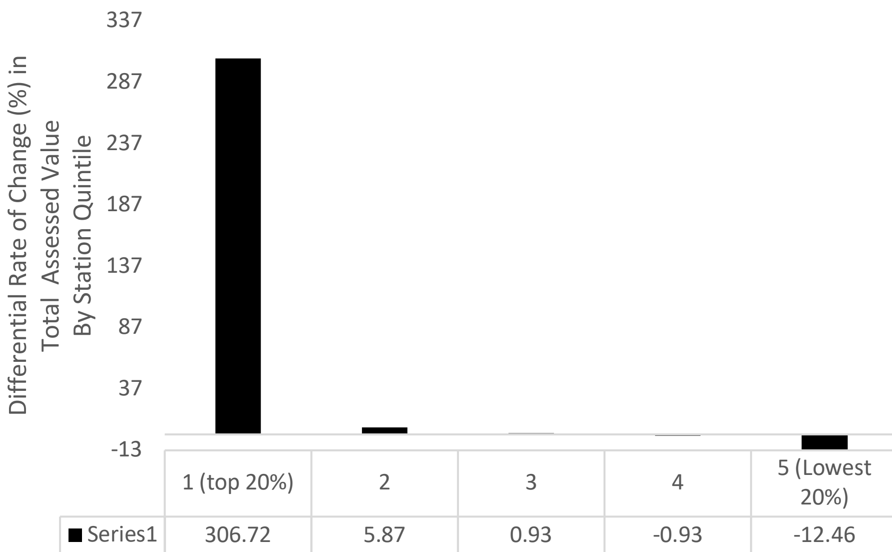


Figure 26: Differential (mean) rates of change in total assessed value over time, by quintile.

Station characteristics

Where treatment areas (Transit Areas of Influence) were limited in size so that they could not overlap, only transit system and station design were statistically significant estimators of differential rates of total assessed value creation, among many station-specific characteristics. Transit system accounted for 19% of variation across stations, and design accounted for an additional 2%.

Where treatment areas (Transit Areas of Influence, within ½-mile of station centroids) were allowed to overlap (so that specific folios might appear within more than one treatment area), only At Grade (Station Design) and Urban Neighborhood (Station Typology) were significant.

Transit agency initiatives and objectives

ANOVA analysis of non-overlapping treatment areas suggests that of the many transit agency goals, objectives, strategies, and perspectives considered, perception of the importance of public-private value creation strategies to the success of transit-influenced or transit-oriented development, and to the success of transit infrastructure investments and projects, were statistically significant estimators of differential rates of total assessed value creation; each accounting for approximately 1% of variation across stations.

Panel regression of data within treatment areas allowed to overlap suggests that transit agencies planning and development goals related to developing *future* ridership, and value creation strategies including providing accommodative development entitlements were statistically significant predictors of differential value creation.

Unanticipated results

Value creation / treatment effect

The Guide to Value Capture Financing for Public Transportation Projects (year), as well as much previous literature based on hedonic price analysis, suggests both that private sector value creation induced through investment in (new) LRT stations is likely to be highly varied, and that such public infrastructure investment is a necessary but not sufficient catalyst for such value creation. Findings presented herein are consistent with those premises presented in the Guide. Nevertheless, these results are surprising both with respect to the extent of the variation in value creation response over time, and how modest the overall treatment effect is on average. Also surprising is the limited extent to which station-specific characteristics (design, typology, character, time in service) were predictive of differential value creation. In context, perhaps any particular result should have been less surprising, perhaps, given the fact that the study period spans that of the Great Recession; during which real property markets were inefficient at best and non-functional or dysfunctional at worst.

Specific market, market conditions, and other (unknown) factors

It is not surprising that "transit system" as proxy for location, market, legal and political jurisdiction, and transit agency institutional characteristics, accounts for approximately

19% of observed variation in differential value creation rates under the ANOVA analysis. It is a bit surprising, however, that combined with all other statistically significant independent variables, the fully controlled model estimating total assessed valuation accounts for only 28% of the variation in differential value creation rates. This is noteworthy because it underscores the importance of understanding the many nuances of environmental, legal, financial, cultural, market and sub-market conditions defining the opportunity for value creation in any particular station area, as well as characteristics or peculiarities of the built environment (Gakenheimer et al., 2011; Song & Quercia, 2008). The value creation that can be induced in response to new transit infrastructure investment may result in significant neighborhood change. Such change may be dependent on an array of factors in addition to new or expanded transit service (Quercia & Galster, 2000). Market price/value responsiveness to new infrastructure investment may also be dependent on the extent to which new development and/or redevelopment is already underway for other reasons (Simons, Quercia, & Levin, 1998).

Contribution of land and improvement to total assessed value

One of the vagaries of assessed valuation methodologies is that although the total assessed value of a tax folio is comprised exclusively of the assessed values of land and improvements comprising the property, total assessed value often does not equal the sum of assessed value-land and assessed value-improvements. Tax assessors may adjust one or more elements of assessed valuation for any of a number of policy-related or strategic reasons. This is one reason that rates of assessed value creation for land and improvements were considered in addition to, and separately from, total assessed values.

The treatment effect observed on assessed values of improvements within treatment areas defined (constrained) so as not to overlap each other was significantly larger, on average, than that for land. In the aggregate, assessed improvement(s) values grew 4.35% faster in treatment areas than in control, whereas assessed land values grew only 3.28% faster within treatment areas. The extent to which the treatment effect explained variation in differential value creation was approximately twice that for assessed improvement value and that for assessed land value; approximately 2% compared to approximately 1%. In addition to which, although the treatment-time interaction effects were significant over the entire period for assessed improvement values, the effect was not significant in any individual year for assessed land value.

These results are counterintuitive with respect to theory suggesting that economic benefits of mobility and accessibility become capitalized into land values per se. The distinction between benefits of proximity to transit stations being capitalized into land or buildings (improvements) has public policy and strategy implications, particularly with respect to the notion of land value taxation.

Henry George's theory, ultimately in support of the equity, efficiency, and efficacy of land value taxation, was that land values increase and decrease according to the level of public investment, particularly in response to increased utility which might result from transportation or transit infrastructure and the intensifying land used that may accompany such public investment. (George, 1879) If, as a practical matter, increases in total assessed value resulting from beneficial public infrastructure benefit are realized or recognized disproportionally as improvement rather than land values, any theoretical appeal of land value taxation may be less clear in application.

Parking and station character

Prior to evaluating prospective covariates for collinearity, it was assumed that the number of vehicular parking spaces provided by transit agencies at each station would be highly correlated with stations' designation as park-and-ride or walk-and-ride, which they were not. Additionally, it was anticipated that such station character would be a significant determinant of differential value creation, which it was not.

Station typology

In general, the fact that so few station-specific characteristics were statistically significant was unexpected. As expected, one of these, station design, was a statistically significant predictor of differential total assessed value creation, and of assessed improvement(s) value creation (although not of assessed land value or folio density). It was anticipated that station typology (descriptive of stations' economic location within a market's urban fabric) would be a significant predictor of differential value creation, which it was not.

Insignificant demographic covariates

That so few demographic variables describing populations within LRT station areas were statistically significant was surprising. Only per capita income and vehicles per household were significant under ANOVA, and only the extent of rent burdened households was significant under the panel regression (based on a slightly different data set and different definition of treatment area). It was presumed, for example, that the extent of differential value creation in response to new infrastructure investment might be significantly correlated with the extent of owner occupancy (Stegman, Quercia, & Davis, 2007).

Transit agency perspectives

Although there were no preconceived notions about which particular transit agency goals, objectives, strategies, or perspectives might turn out to be significant predictors of value creation, that transit agencies perception of "public-private value creation strategies as important to the success of transit infrastructure investments and projects [and] the success of transit-influenced or transit-oriented development, as indicated under ANOVA" was unanticipated.

Panel regression of data within treatment areas allowed to overlap suggests that transit agencies planning and development goals related to developing *future* ridership, and value creation strategies including providing accommodative development entitlements were statistically significant predictors of differential value creation.

Other considerations

During the period of study, including those years so significantly and adversely impacted by the Great Recession, it appears that market forces and characteristics other than those captured within the covariates in this study influence differential value creation in proximity to new LRT systems to a significantly greater extent than the treatment (new infrastructure/investment) itself. This underscores the importance of understanding and underwriting such market conditions and factors before undertaking projections with respect to anticipated levels of value creation. Differential rates of assessed value creation varied widely across transit systems and individual stations. TAIs in the top 20% of differential value creation experienced average annual growth rates 30.67% faster than that of control areas, whereas TAI's in the bottom quintile experienced average annual growth rates 1.25%, less than those within control areas. Significantly positive differential value creation was clustered within a small number of transit systems and within a relatively few number of stations along several lines.

Differential rates of assessed value creation are found to accrue disproportionately to improvements (and indirectly to folio density) rather than to land. The interaction effect between time and treatment was significant in more years for improvements and folio counts than for total assessed value, and in no year for land.

Significant covariates included transit system (location), accounting for 19% of the differential rate of change in total assessed value per acre over time; per capita income (at the census block-level), accounting for an additional 3% of variation; station design, accounting 2% of variation; transit agency perceptions of public-private value creation strategies as important 1) to the success of transit infrastructure investments and projects, and 2) to the success of transit-influenced or transit-oriented development, accounting for an additional 1% of variation each. Significantly positive differential value creation occurred predominantly near at-grade stations.

Of numerous demographic covariates evaluated, only per capita income and vehicles per household were significant, predicting 4% and 2%, respectively, of differential rates of change over time (the interaction of covariate and time) between treatment and control groups.

The treatment effect observed on assessed values of improvements was significantly larger, on average, than that for land. In the aggregate, assessed improvement(s) values grew 4.35% faster in treatment areas than in control, whereas assessed land values grew only 3.28% faster within treatment areas. The extent to which treatment explained variation in differential value creation was approximately twice that for assessed improvement(s) value and that for assessed land value; approximately 2% compared to approximately 1% respectively. In addition to which, although the treatment-time interaction effects were significant over the entire period for assessed improvement values, the effect was not significant in any individual year for assessed land value.

A question for future consideration:

Is it plausible that under some market conditions (or in some locations), particularly in consideration of predevelopment land speculation, new rail transit line/station investment may induce value creation within strong markets (or sub-markets) and impede value creation within weak ones?

Real property surrounding numerous stations experienced negative differential value creation over the study period. This was true even along lines that experienced robust positive differential value creation surrounding some stations. In addition to underscoring the prospective importance of market and sub-market conditions (and timing), negative differential value creation begs a question regarding the possibility that new transit infrastructure investment might impede rather than induce new and higher private sector value creation. This possibility is buttressed by anecdotal observation of multiple prospective development tracts that have remained fallow for years after development of new, high quality, transit infrastructure, even in generally robust metropolitan markets.

One possible explanation for this might include pre-transit-development land speculation. In a less than perfectly efficient land or real estate market, investors might be overly optimistic regarding value impacts of transit proximity/accessibility and bid up land prices without adequately discounting for other local and sub-market factors. One of a number of alternative explanations might involve regulators requiring development density or quality (through zoning or other entitlement mechanisms) exceeding that which a particular market location can support. Although value capture strategies have not yet been implemented broadly in the context of new transit infrastructure investment, value capture exactions will impact some market locations more than others. These could act as impetus to development in some locations (e.g. such as for suburban development with master-planned communities subject to special assessments), and impediments to development elsewhere. This suggests opportunity for future research, in addition to those which follow.

Suggestions for future research

These and other considerations raise many questions for future inquiry. What are the economic, market, and sub-market factors that allow robust differential value creation in some places, but flat or negative outcomes in others? What factors, perhaps including institutional practices or constraints, result in value creation becoming (apparently) disproportionately assessed to values of improvements as opposed to land? Why were rates of differential value creation so much greater within some markets (transit systems) than others over the same period of years?

Opportunities for case study analyses

Several of the recommendations for future research could be carried out through individual or comparative transit system, transit line, or transit station case studies. Very high levels of aggregate differential value creation occurred near stations studied within the Phoenix Valley Metro system and the Salt Lake City TRAX system compared to those within other transit systems. Differential value creation along Charlotte's Blue Line (as well as along other lines in other systems) varied from very highly positive to negative. Understanding differences in market conditions and timing issues across metropolitan regions and/or differences in (station-specific) sub-market conditions along a single transit line might shed important light on factors contributing to the significant variation in differential rates of value creation revealed in this study.

Such a case study might also help to shed greater light on the timing of predevelopment land speculation relative to announcements of corridors and alignments, determination of station locations, and development of stations. While available data did not allow such analysis across all transit lines in this study, the data straddled these benchmark dates, as well as commencement of service, for several lines.

Understanding variation in differential value creation rates

Differential value creation rates are significantly skewed across the 14-transit systems observed in this study. Differential value creation rates are even more highly skewed across the 229 stations observed. This suggests that there is significant variation not only between specific transit lines and markets (metro areas), but within transit lines and systems. This is consistent with anecdotal observation of individual systems such as the Charlotte Blue Line which has experienced robust development and value creation within some few station areas, but where other station areas have remained fallow for years.

Results of this study provide some insight into which transit systems, of those considered, have experienced robust positive value creation in proximity to LRT stations and those that have not. Likewise, data compiled for this study identify individual stations that have benefitted from very high rates of differential value creation, those that have experienced negative differential value creation, and the many in-between.

Individual stations along specific (high and/or low performing) transit lines might now be evaluated more closely in an effort to identify factors that explain intra-transit line variation in performance, as well as to see if covariates that were insignificant predictors in this aggregated study might be of greater relevance at a smaller scale.

Understanding assessment methodology

The finding that differential rates of value creation disproportionally accrues to assessed values of improvements rather than land has potential public policy and tax policy and well as (strategic) value capture strategy implications. Greater understanding of how undifferentiated transaction prices are allocated variously to land or to improvements through appraisal and tax assessment processes may be beneficial in several respects. The relationship between that portion of value assessed to land and that portion assessed to improvements may have other effects as well, including implications for urban form (Song & Zenou, 2006).

Understanding sub-market (intra-transit line) characteristics

That the model only explains approximately 28% of observed variation in differential value creation rates from station to station suggests that there are significant factors at play in addition to the covariates considered herein. Some of these may include very fine grain sub-market, regulatory, environmental, institutional, geographic, topographic factors as well as neighborhood characteristics. Identification and understanding of such factors would be useful for economic impact assessment and financial modelling related to consideration of new transit (or other transportation) infrastructure investment.

Understanding predevelopment land speculation and timing of value creation

The original proposal for this research, based on the prospect of 30-years of assessed value data and 1,100 relevant U.S. light rail stations as opposed to 11-years of data and the 229 stations observed in this study, included measuring differential rates of differential value creation prior and subsequent to the putative "treatment" defined as commencement of service at each station. Reduction in scope of available assessed value data meant that more than a few of the commencement of service dates for individual stations and lines fell outside the date range of available data. This analysis was dropped in an effort to maintain as broad a scope (and as many stations under observation) as possible.

The opportunity now exists to consider that subset of stations with commencement of service dates somewhere between 2005 and 2015 in an effort to understand and model the extent and timing of anticipatory predevelopment land speculation and/or other value creation.

Implications for practice

Public-sector investment in transportation infrastructure has long been a driver of private-sector investment and value creation. Ongoing consideration of prospectively massive transportation infrastructure investment and re-investment within the United States combined with increasing interest in value capture as a finance strategy focus ever greater attention on inducement of value creation through new LRT (and other) infrastructure investment. Any seductive presumption that "if we [the public-sector] build it [new transit infrastructure], they [producers of incremental value creation] will come," is inadequate and potentially dangerous.

Economic, market, and station-specific sub-market forces appear to wield significantly greater determinative power with respect to value creation than does infrastructure investment itself.

Development that occurs surrounding newly-developed LRT stations is often more intensive, more complicated, and perhaps more risk-laden than competitive (non-transit-influenced) projects. Policy makers, planners, transit professionals, and financiers may need to facilitate earlier and more comprehensive strategic planning and engagement in the value creation process in order to realize the significant potential value creation that can occur under the right circumstances. Fruitful public-private partnership and strategic engagement will require much greater understanding of the economic, market, and sub-market forces that determine the extent of differential value creation than may currently exist. Value capture strategies that encourage and reinforce continued value creation, rather than creating competitive disadvantage and economic disincentive, will remain entirely dependent on robust value creation and, therefore, on successful value creation strategies.

APPENDIX I – Survey Instrument

THE UNIVERSITY *of* NORTH CAROLINA *at* CHAPEL HILL

Value Creation Resulting from Public Investment in Light Rail Transit Infrastructure and Transit Oriented Development – **Survey Instrument**

Dear ___________________

Thank you once again for agreeing to cooperate in this academic research effort. Transit line-specific versions of this survey/questionnaire are being distributed to transit planners and transit agency professionals associated with twenty-three (23) light rail transit (LRT) lines in the United States. Approximately 300-stations along these lines have been selected for study based on a number of criteria including commencement of service between 2005 and 2014.

Data requested through these surveys address individual physical station characteristics and the extent to which various value creation and value capture strategies may have been incorporated into LRT planning and development. These data will be employed in a study of changes in assessed valuation, and residential repeat sales price data, over time (10-years). Changes in values associated with real property in proximity to stations (within transit areas of influence) will be compared to those of surrounding areas further from LRT stations.

I have attempted to simplify this survey instrument, tailor it to each LRT system or line, and make it mechanically easy to respond to. I am hopeful that completion of this form will not require a great deal of time on your part. In any event, your time and effort are very much appreciated.

Sincerely,

Bill Bishop, Ph.D. candidate
Department of City and Regional Planning
University of North Carolina at Chapel Hill

bill@abetterplace.us
919-619-4169

Directions for completing this survey

This survey/questionnaire can be completed on your computer. Please save this Microsoft Word file to your computer, and enter responses directly in this file as follows:

- Please use your mouse to navigate to fields or check boxes you wish to answer.
- To select a check box ☐, click on the center of the box and an "**X**" will appear.
- To change or deselect a box response, click on the box again and the "**X**" will disappear.
- To answer a question that requires a number, name, or comment, please click on the answer box , and begin typing. You may type as much as you wish. The box with expand to accommodate your text.
- Once you have completed the survey, please resave the file and email a copy to me at bill@abetterplace.us.

If you have questions or concerns about this questionnaire, please contact Bill Bishop at bill@abetterplace.us *or 919-619-4169. Thank you for your cooperation with this research.*

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Value Creation Resulting from Public Investment in Light Rail Transit Infrastructure and Transit Oriented Development – **Survey Instrument**

CONTACT INFORMATION

Transit Agency: ______________________________

Light Rail Transit Lines: ______________________________

Name of Respondent: ______________________________

Title: ______________________________

Email Address: ______________________________

Telephone: ______________________________

1) Please indicate your primary area of responsibility:
- ☐ Management
- ☐ Planning
- ☐ Development
- ☐ Finance
- ☐ Operations
- ☐ Other

2) How many years have you been employed with your organization?
- ☐ 0 to 1
- ☐ 2 to 5
- ☐ 6 to 10
- ☐ More than 10

3) What was your position at time of subject LRT development?

Check if employed elsewhere at time of development: ☐ Employed elsewhere

If you have questions or concerns about this questionnaire, please contact Bill Bishop at bill@abetterplace.us or 919-619-4169. Thank you for your cooperation with this research.

Individual Station Characteristics

4) Please select the best characterization of a) station design, b) station typology, and dominant station character for each station from the indicated drop-down lists (select). Please indicate the total number of parking spaces provided at each station in the space provided.

Charlotte BLUE LINE	Station Design	Station Typology	Dominant Character	No. of Parking Spaces
7th Street	(select)	(select)	(select)	
Stonewall	(select)	(select)	(select)	
Carson	(select)	(select)	(select)	
Bland Street	(select)	(select)	(select)	
East/West Boulevard	(select)	(select)	(select)	
New Bern	(select)	(select)	(select)	
Scaleybark	(select)	(select)	(select)	
Woodlawn	(select)	(select)	(select)	
Tyvola	(select)	(select)	(select)	
Archdale	(select)	(select)	(select)	
Arrowood	(select)	(select)	(select)	
Sharon Road West	(select)	(select)	(select)	
I-485/South Boulevard	(select)	(select)	(select)	

If you have questions or concerns about this questionnaire, please contact Bill Bishop at bill@abetterplace.us or 919-619-4169. Thank you for your cooperation with this research.

Planning and Transit Objectives

5) What were the primary objectives driving planning/development of subject transit line and station areas? (Please check all that apply.)

- ☐ Serving existing commuters based on pre-transit residential and employment patterns
- ☐ Serving anticipated residents and workers drawn to new development near transit stations
- ☐ Inducing transit ridership
- ☐ Relieving roadway congestion
- ☐ Economic development
- ☐ Growth management, environmental, or other public policy mandates or objectives
- ☐ Political or public initiatives or agenda
- ☐ Initiatives of commercial interests or private developers

6) What value creation strategies were employed in connection with transit line/station planning and development?

- ☐ None: no specific value creation strategies were implemented
- ☐ Strategic partnership between public and private interests
- ☐ Land use, zoning, entitlement enticements
- ☐ Complementary (non-transit) public infrastructure investment
- ☐ Land assemblage, acquisition, or other real estate strategies?
- ☐ Other (please specify)

7) When did substantive engagement toward strategic public-private partnership commence?

If you have questions or concerns about this questionnaire, please contact Bill Bishop at bill@abetterplace.us or 919-619-4169. Thank you for your cooperation with this research.

Value Capture Strategies

8) What specific value capture mechanisms were employed as part of the infrastructure funding strategy?

- ☐ Joint Development
- ☐ Negotiated Exactions
- ☐ Tax Increment Financing (TIF)
- ☐ Special Assessments Impact Fees
- ☐ Land Value Taxation
- ☐ Naming Rights
- ☐ Other, please describe:

- ☐ NONE: No Value Capture

9) When were value capture strategies and/or mechanisms developed and negotiated?

Please approximate date or define otherwise:

10) How significant/important was value capture strategy to financial viability or project success?

- ☐ Very Important
- ☐ Significantly Important
- ☐ Moderately Important
- ☐ Somewhat Important
- ☐ Slightly Important
- ☐ Not Important

11) In your opinion, how important are public-private value creation strategies to the success of transit-influenced or transit-oriented development?

- ☐ Very Important
- ☐ Significantly Important
- ☐ Moderately Important
- ☐ Somewhat Important
- ☐ Slightly Important
- ☐ Not Important

If you have questions or concerns about this questionnaire, please contact Bill Bishop at bill@abetterplace.us or 919-619-4169. Thank you for your cooperation with this research.

12) In your opinion how important are public-private value creation strategies to the success of transit infrastructure investments and projects?

- ☐ Very Important
- ☐ Significantly Important
- ☐ Moderately Important
- ☐ Somewhat Important
- ☐ Slightly Important
- ☐ Not Important

13) In your opinion how important is value capture to the success of transit infrastructure investments and projects?

- ☐ Very Important
- ☐ Significantly Important
- ☐ Moderately Important
- ☐ Somewhat Important
- ☐ Slightly Important
- ☐ Not Important

14) In your opinion, how has the importance of value capture changed over time?

15) What do you perceive to be the greatest barriers to realizing transit-related value capture?

16) What lessons has your experience provided with respect to transit infrastructure related value creation and value capture?

17) Do you have any suggestions or recommendations for implementing future transit-related value creation and/or value capture projects?

This survey is undertaken in connection with a study of value creation associated with proximity to light-rail transit stations in the United States. The investigator is William L. Bishop, Ph.D. candidate, Department of City and Regional Planning, University of North Carolina at Chapel Hill.

If you have questions or concerns about this questionnaire, please contact Bill Bishop at bill@abetterplace.us or 919-619-4169. Thank you for your cooperation with this research.

APPENDIX II – Stations Excluded from Analysis

The following stations were eliminated from analysis due to insufficient treatment area data, insufficient control area data, extensive overlap of folios within treatment area with those in adjoining station areas, missing data, insufficient control area comparables, and/or location of station on peninsula surrounded by water bodies.

- Dallas
  - North Carollton/Frankfort
  - Trinity Mills
- Denver
  - Pepsi Center
  - Sports Authority Field
  - Theater District
  - Colfax at Auraria
  - Auraria West
  - 10th & Osage
  - Alameda
  - Louisiana & Pearl
  - I25 & Broadway
- Houston
  - Memorial Hermann Hospital
- New Jersey Transit – Hudson-Bergen Line
  - 22nd Street
  - 8th Street
- New Jersey Transit – River Line
  - Aquarium
- Los Angeles
  - La Brea
  - La Cienega
- Minneapolis
  - 28th Avenue
  - American Boulevard
  - Bloomington Central
  - Fort Snelling
- Phoenix
  - Center Parkway
  - Priest Drive & Papago Park
- Portland
  - Delta Park/Vanport
  - Mount Hood Avenue
  - NW 5th/6th & Couch/Davis
  - Pioneer Courthouse
  - PSU South, SW 5th/6th
  - SW 5th/6th & Jefferson
  - SW 5th/6th & Oak/Pine
  - SW 6th & College
  - SW 6th & Montomgery
- Salt Lake City
  - 5600 West Old Bingham Highway
  - Decker Lake
  - Fort Douglas
  - South Jordon Parkway
  - University Medical Center
  - University South Campus
- Seattle
  - SODO

APPENDIX III – GIS Data Processing

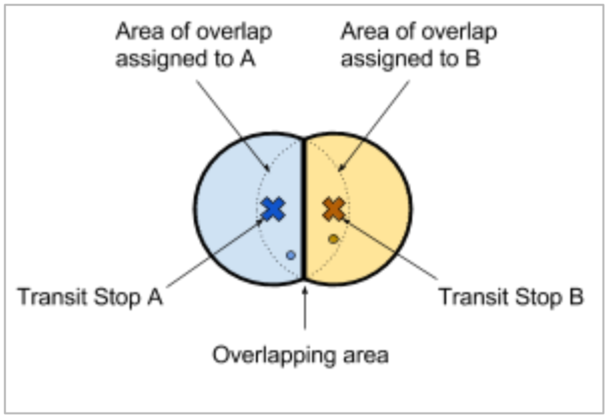
The following description of GIS data processing and methodology is provided by Phillip McDaniel, GIS Librarian, Davis Library at the University of North Carolina at Chapel Hill.

TRANSIT STATION TERRITORIES

Background

One of the main goals of this effort was to assign folios to transit stops based on proximity. This assignment of folios was done at two different geographic specifications: within ½ mile, and between 1 and 2 miles. The transit stations were processed to create two territories per station: a ½ mile Euclidean buffer (hereafter referred to as TA)(maximum total area = 0.785 sq miles), and a 1 to 2 mile ring buffer (hereafter referred to as CA)(maximum total area = 9.426 sq miles).

The requirements were different for the construction of the TAs and CAs, necessitating different processing for each type. Specifically, the TA for each transit stop was constructed such that there would be no overlap with the TAs of adjacent transit stops (see diagram, below). In those areas where there was overlap between TAs, the overlapping area was split (roughly evenly), with a portion being assigned to each of the overlapping TAs. The partitioning of space was done in this way so that CoreLogic folios would be assigned to one, and only one, transit stop- that is, there is no double, triple, etc, counting of folios within the TAs. For example, also in the diagram that follows, even though it falls within ½ mile of both transit stop A and B, the blue dot is assigned to stop A since it it closer to stop A than it is to stop B (likewise, the orange dot is assigned to stop B due to its closer proximity to stop B).



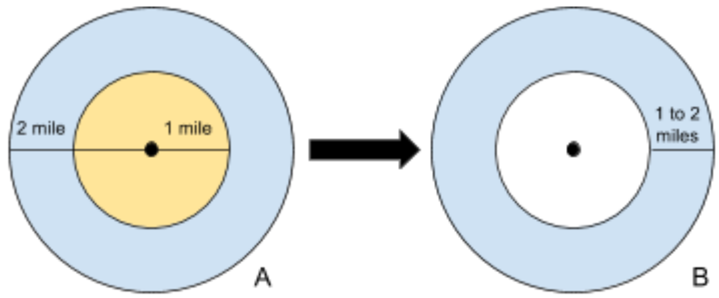
The CAs were not bound by this overlap restriction, however, so the number of overlapping CAs would be higher or lower depending on the density of transit stops (i.e. cities with a large number of transit stops in close proximity could have areas that are overlapped by many CAs). Further, any folios that fell within an area of CA overlap were assigned to each of the overlapping CAs. For a conceptual example, in the diagram above (even though it doesn't show ring buffers), since the blue point is within an area of overlap between both A and B, it would be assigned to both transit stops (likewise for the orange point). In the more densely populated urban study sites, some folios might be assigned to 10 or more transit stops.

Processing: Control Areas (CAs)

The transit stop points for all cities were first projected from a geographic coordinate system (GCS) to a projected coordinate system (Albers Equal Area Conic, USGS version) so that distances and areas could be accurately calculated. Once projected, the CA buffers were created using the [BUFFER] tool in ArcMap 10.4.1. This tool generates Euclidean (i.e. as the crow flies) buffers at user defined intervals. Since the CA buffers were rings that only covered areas between 1 and 2 miles from the transit stops, a two step process was employed:

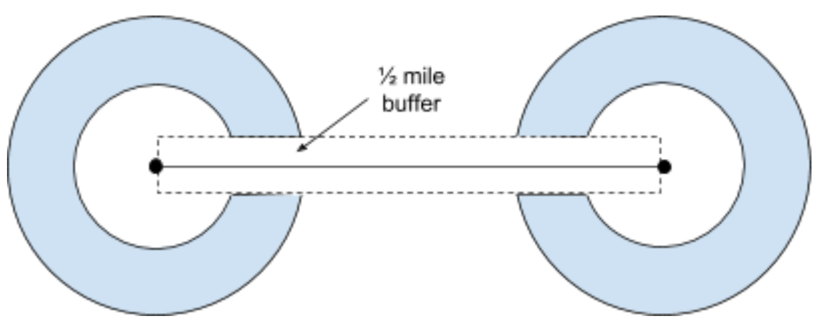
1. Create 1 and 2 mile buffers around each transit stop (A, below).
2. Erase the 1 mile buffer from the 2 mile buffer (B, below). This step clips out the 1 mile

buffer from the middle of the 2 mile buffer, resulting in a 1 to 2 mile ring around each station.



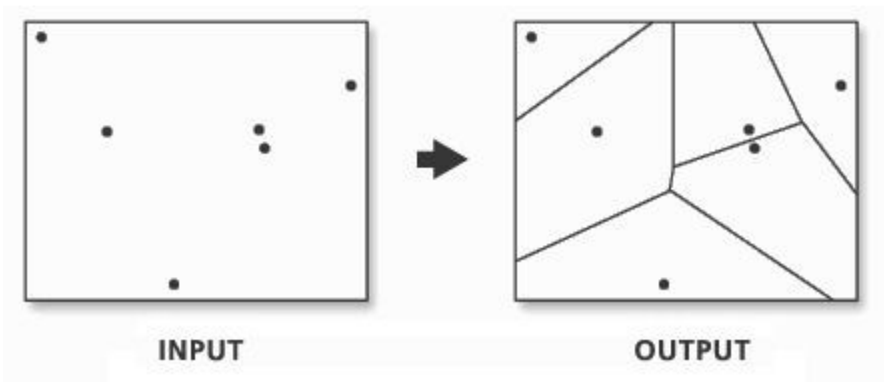
A final processing sequence was performed on the CAs in order to remove the areas in close proximity (½ mile) to transit lines:

1. Using the [BUFFER] tool, creat ½ mile buffers constructed around transit lines (shown in the dashed line, below).
2. Erase the transit line buffers from the 1 to 2 mile CA buffers. This step clips out the ½ mile transit buffers from the 1 to 2 mile CA buffers (see diagram, below). This process of clipping out the ½ mile transit line buffers effectively removes territory from the CAs, so any folios that fall in those areas will not be included in the CAs for transit stops.



Processing: Treatment Areas (TAs)

In addition to the processing described above, the transit stops were processed in order to create non-overlapping TAs. Instead of simply creating ½ mile buffers around each station, the TAs were further processed to eliminate any areas of overlap with adjacent transit station TAs. Specifically, Thiessen polygons were constructed, then a UNION function was run with the ½ mile buffers to create non-overlapping territories for each transit stop. Thiessen polygons are polygons whose boundaries define the area that is closest to each point relative to all other points:

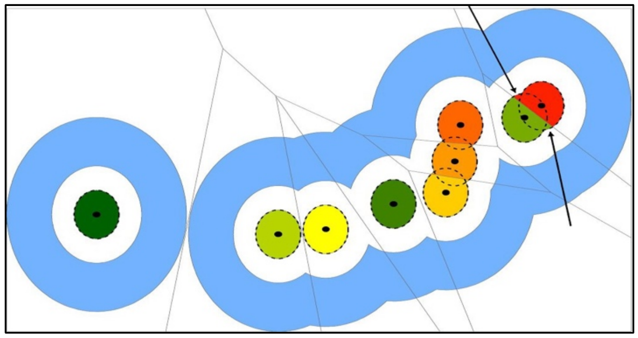


This Thiessen polygon and UNION approach was used for three main reasons:

1. Due to processing complexities involved with precisely bisecting the areas of overlap between the ½ mile transit stop buffers
2. Time intensive to manually interpret and delineate boundaries
3. Difficult to accurately reproduce results or extend research to other study sites without a clearly defined workflow

The diagram below provides a conceptual overview. The ½ mile transit buffers are defined by the dashed lines surrounding the circles. The Thiessen polygons are defined by the thin gray lines. When a UNION is performed on these two layers, the Thiessen polygons and ½ mile buffers create a new set of polygons that contain all overlap combinations (i.e. a Venn

Diagram). For each transit stop, the TA is then determined by areas that are both within its Thiessen area and within its ½ mile buffer.



In a few instances, due to the configuration of transit stops, there are slight differences between the bisection of overlapping ½ mile buffers and Thiessen polygon territories. In the above diagram, these discrepancies are indicated by the arrows to the right. In this scenario, for the two easternmost stops, there are some areas within the ½ mile buffer of the red transit stop that are actually closer to the green transit stop, and vice versa. When this occurs, the default is to assign those areas based on the transit stop Thiessen polygon that they fall within.

The processing of the TAs was as follows:

1. Create ½ mile buffers around each transit stop using the [BUFFER] tool in ArcMap.
2. Create Thiessen polygons around each transit stop using the [CREATE THIESSEN POLYGONS] tool in ArcMap. The resulting polygons contain all of the attributes from the input point features (e.g. station name, station ID, etc.)
3. Combine the 1.2 mile transit stop buffers and the transit stop Thiessen polygons using the [UNION] tool in ArcMap. The resulting polygon file contains features for all possible overlaps, listed below:
    a. ½ mile buffer - Thiessen

b. No ½ mile buffer - Thiessen

4. Each polygon overlap feature also contains the attributes of the input features. For example, in scenario a above (½ mile buffer - Thiessen), a feature would have information from both the ½ buffer input and the Thiessen polygon input. In instances where the ½ mile buffer for transit stop ABC is fully within the Thiessen polygon for ABC, there will only be one record in the UNION file with ½ mile buffer attributes for transit stop ABC. However, if transit stop ABC's ½ mile buffer were to overlap with transit stop DEF's ½ mile buffer, there will be two records in the UNION file for transit stop ABC- one for the intersection with its own Thiessen polygon, and one for its intersection with the Thiessen polygon of DEF.

In the example table below, several overlap scenarios are shown:

1. ABC intersects DEF
2. DEF intersects ABC and GHI
3. GHI intersects DEF
4. JKL does not intersect any other ½ mile buffers

½ Mile ID	Thiessen ID
ABC	ABC
ABC	DEF
DEF	DEF
DEF	ABC
DEF	GHI
GHI	GHI
GHI	DEF
JKL	JKL

In the above scenario, the TAs would then be constructed based on a shared Thiessen ID. The color coding shows the UNIONed polygons that will be combined to form the TA for each transit stop:

1. Orange is the TA for ABC
2. Green is the TA for DEF
3. Blue is the TA for GHI
4. Purple is the TA for JKL

CORELOGIC FOLIO ASSIGNMENT

Compared to workflow to construct the CAs and TAs, the processing to associate folios with station CAs and TAs was relatively straightforward (I will lean on Matt to write some sentences about the specific heavy lifting involved to pull meaningful information from the massive data tables). As stated above, the main difference between the TAs and CAs is that an individual folio could only be assigned to a single TA, whereas an individual folio could be assigned to as many TAs as it falls within.

The first step in processing the folios was to plot the folios based on their X and Y (longitude and latitude) coordinates in order to create a point GIS file. Plotting the points was a simple process, requiring only that the X and Y fields be properly specified so that the points could be displayed in their correct geographic locations. This point file was subsequently used as an input to a second tool- [SPATIAL JOIN].

The tool used to join the folio data to the transit station TAs and CAs was [SPATIAL JOIN]. This tool joins attributes from one feature to another based on the spatial relationship. In this instance, the transit stop TAs and CAs were spatially joined to the folios.

For the TAs, the join type was one-to-one, where a folio could only fall within a single station's TA. The output was a shapefile (a common vector GIS format) containing points for the folios that intersected a TA, with the transit station ID that was intersected appended to the folio attributes. In this file, which contained only the folios that were within a TA, each folio was only represented once.

For the CAs, the join type was one-to-many, where a folio could fall within any number of CAs. The output for this was a shapefile containing points for the folios intersected a CA, with the transit station ID that was intersected appended to the folio attributes. In this file, however, each folio could be included multiple times, once for each intersection with a different CA. For each instance of a folio, a different station's CA was appended to the folio attributes.

Much of what Matt did involved using the TA and CA folio files to summarizing the folios by transit station ID. For example, for each transit ID in the TA folio file, calculate the mean property value. Or, for each transit ID in the CA folio file, calculate the mean value per acre.

APPENDIX IV - Selection of demographic covariates

The original model specification included a greater number of independent variables than could be accommodated due to absolute constraints of the ANOVA statistical analysis software. A large number of prospectively relevant demographic covariates were obtained from the 2010 American Community Survey data at the census block-level. These were analyzed in preliminary models and wherein total assessed value was regressed on them to identify and eliminate variables with significant collinearity. The resulting list of demographic (control) covariates included in the final model comprised median household income, gross rent burden greater than 30%, persons per household, percent of dwellings owner occupied, total vehicles per household, and dwellings percent vacant.

- Age-Sex: SEX BY AGE
- Age-Sex: MEDIAN AGE BY SEX
- Educational Attainment: SEX BY EDUCATIONAL ATTAINMENT FOR THE POPULATION 25 YEARS AND OVER
- Income: MEDIAN HOUSEHOLD INCOME IN THE PAST 12 MONTHS (IN 2015 INFLATION-ADJUSTED DOLLARS)
- Income: PER CAPITA INCOME IN THE PAST 12 MONTHS (IN 2015 INFLATION-ADJUSTED DOLLARS)
- Employment Status: EMPLOYMENT STATUS FOR THE POPULATION 16 YEARS AND OVER
- Housing: OCCUPANCY STATUS
- Housing: TENURE
- Housing: TOTAL POPULATION IN OCCUPIED HOUSING UNITS BY TENURE

- Housing: AVERAGE HOUSEHOLD SIZE OF OCCUPIED HOUSING UNITS BY TENURE
- Housing: TENURE BY VEHICLES AVAILABLE
- Housing: AGGREGATE NUMBER OF VEHICLES AVAILABLE BY TENURE
- Housing: GROSS RENT AS A PERCENTAGE OF HOUSEHOLD INCOME IN THE PAST 12 MONTHS

Of these, demographic covariates included in the final model included Median Household Income, Persons Per Household, Gross Rent Burden > 30%, Percent Dwellings Owner Occupied, Total Vehicles Per Household, and Dwellings Percent Vacant.

Selection of independent covariates for inclusion in model(s)

Covariate evaluation began with identification of potentially confounding variables (which variables resulted, initially, in a highly complex ANOVA model). Although inclusion of all available covariates allowed examination of each possible covariate's effect, it also interfered with model execution. This was exemplified by the model's inability to calculate many of the two- and three-way interactions initially considered. Additionally, between-effects for several single variables could not be estimated. These included the transit agency goals and objectives, and value creation and value capture strategies. Following removal of variables for which between-effects could not be estimated, the model was reconstructed excluding three-way (or greater) interactions excluded. The resulting, somewhat reduced, model was assessed to evaluate remaining variables for collinearity. Vehicles per renter household and vehicles per owner-occupied household were too highly correlated to be included together in the model. Vehicles per owner-occupied household had the stronger effect and was retained. Vehicles per renter household excluded. Other variables pre-assumed to be correlated were not problematic upon examination. These included parking spaces and station character, as well as median household income and per capita income. In these cases, all variables were retained. The final four models controlled for station-specific characteristics and transit agency goals and objectives as well as transit system (location) and demographic characteristics included 17 covariates, in addition to the effect of time and treatment.

APPENDIX V – Transit Agency Survey Data – Descriptive Statistics

Statistics descriptive of survey responses are reflected in Tables 13 - 16.

Table 22: Descriptive statistics – station characteristics

		n	%
Station Characteristics			
Station Design	Elevated	25	10.9
	At Grade	191	83.4
	Open Cut	9	3.9
	Underground	4	1.7
Station Typology	Downtown-CBD	34	14.8
	Urban Center	17	7.4
	Urban Neighborhood	89	28.9
	Suburban Town Center	18	7.9
	Suburban Neighborhood	46	20.1
	Campus, Entertainment, Special	21	9.2
	Other	4	1.7
Station Character	Walk-and-Ride	146	63.8
	Park-and-Ride	83	36.2

Table 13: Descriptive statistics – transit line design/development objectives

		n	%
Transit line design/development objectives			
Serving existing commuters based on pre-transit residential and employment patterns			
	No	80	34.9
	Yes	149	65.1
Serving anticipated residents and workers drawn to new development near transit stations			
	No	119	52.0
	Yes	110	48.0
Inducing transit ridership			
	No	55	24.0
	Yes	174	76.0
Relieving roadway congestion			
	No	127	55.5
	Yes	102	44.5
Economic development			
	No	84	36.7
	Yes	145	63.3
Growth management, environmental, or other public policy mandates or objectives			
	No	160	69.9
	Yes	69	30.1
Political or public initiatives or agenda			
	No	117	51.1
	Yes	112	48.9
Private sector commercial interests or development initiatives			
	No	227	99.1
	Yes	2	0.9

Table 14: Descriptive statistics - value creation strategies

		n	%
Value Creation Strategies			
None: no specific value creation strategies were implemented			
	No	176	76.9
	Yes	53	23.1
Strategic partnership between public and private interests			
	No	199	86.9
	Yes	30	13.1
Land use, zoning, entitlement enticements			
	No	142	62.0
	Yes	87	38.0
Complementary (non-transit) public infrastructure investment			
	No	174	76.0
	Yes	55	24.0
Land assemblage, acquisition, or other real estate strategies?			
	No	160	69.9
	Yes	69	30.1
Other			
	No	218	95.2
	Yes	11	4.8

Table 15: Descriptive statistics - value capture strategies

		n	%
Value Capture Strategies			
Joint Development			
	No	201	87.8
	Yes	28	12.2
Negotiated Exactions			
	No	224	97.8
	Yes	5	2.2
Tax Increment Financing (TIF)			
	No	207	90.4
	Yes	22	9.6
Special Assessments Impact Fees			
	No	207	90.4
	Yes	22	9.6
Land Value Taxation			
	No	0	0.0
	Yes	0	0.0
Naming Rights			
	No	224	97.8
	Yes	5	2.2
None: No Value Capture			
	No	63	27.5
	Yes	166	72.5

Table 16: Descriptive statistics - transit agency perspectives

		n	%
Transit Agency Perspectives			
How significant/important was value capture strategy to financial viability or project success?			
	Not Important	187	81.7
	Slightly Important	18	7.9
	Moderately Important	6	2.6
	Significantly Important	9	3.9
	Very Important	9	3.9
How important are public-private value creation strategies to the success of transit-influenced or transit-oriented development?			
	Not Important	30	13.1
	Slightly Important	22	9.6
	Moderately Important	34	14.8
	Significantly Important	112	48.9
	Very Important	31	13.5
How important are public-private value creation strategies to the success of transit infrastructure investments and projects?			
	Not Important	31	13.5
	Slightly Important	22	9.6
	Moderately Important	64	27.9
	Significantly Important	77	33.6
	Very Important	35	15.3
How important is value capture to the success of transit infrastructure investments and projects?			
	Not Important	51	22.3
	Slightly Important	12	5.2
	Moderately Important	68	29.7
	Significantly Important	85	37.1
	Very Important	13	5.7

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