Why station areas succeed: Analyzing North America's largest light rail network.

by

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Abstract

Light rail networks represent a substantial public transportation investment in cities. Common planning practice suggests that the construction of these networks will lead to the construction of denser and less car dependent transit-oriented development. While this is true in most places where light rail is constructed, the development benefits are not realized near each station site. This research tests the “build it and they will come” paradigm for TOD near light rail station areas. We used the Dallas Area Rapid Transit (DART) light rail network as an exemplar for findings potentially applicable to other cities and explored it with a mixed-methods approach using interviews with experts and data modelling. Through a trial-and-error process turning on and off variables in the model, we tested planner’s hypothesis and conventional wisdom about where TOD is most likely to succeed.

Table of Contents

List of Figures

List of Tables

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Chapter 1 - Introduction

From the dawn of civilization, society has been ordered by ordered by how we can move people and things from one place to another. This most basic tenant of planning: the relationship between planning and land use, has been very closely studied. Today, one of the hottest topics is how high quality, frequent transit service can catalyze high-activity development around rail station sites. Planners call this Transit-Oriented Development or TOD. Most US cities now have some sort of rail or high-frequency transit service (Spieler, 2018). There are many reasons to build high quality public transportation, but one of the motives often cited in funding proposals is the new potential for high density real estate development near rail stations (Dong, 2016; Garrett, 2004).

This relationship is almost taken for granted in today's understanding of city planning. Several studies conclude that areas that are served by transit do have a significant increase in property values and attract new transit-centric high-density development (Cervero, 1984; Garrett, 2004; Lewis-Workman & Brod, 1997; Weinberger, 2001). However, the distribution of TODs among the stations in the network are unequal. Even at station sites where high-quality transit service has existed for decades, there are often vacant lots, low-density housing, or other non-transit conducive land uses. Personally, I noticed this issue of underutilized land uses near light rail came while exploring the suburban network of Dallas, Texas, but there are similar observations to be made in networks across the country.

Why should we care? Over the past several decades, federal, state, and local governments have spent billions building new rail systems across the country (Nicholson, 2016). While public transportation investments bring many advantages, investments are prioritized based upon how many riders they will serve every day, and at what cost. That often means that high dollar transit

investments are focused on highway or highway-adjacent rail corridors due to the cheaper to acquire right of way and motivation from drivers who want congestion relief. These systems use park-and-ride lots at stations to encourage ridership (Higashide, 2019; Spieler, 2018; Walker, 2011). While this model is effective at bringing riders to the system, it makes connecting to destinations and station area redevelopments secondary to the network design.

Cities are motivated to encourage TOD. They provide additional tax base, raise land values, and attract more users to the transit service. For many cities facing housing shortages, TODs can mitigate the problems of sprawl. Encouraging that TOD, however, requires an initial investment in quality transit, but that investment does not always reach each station area. Some stations produce dense, walkable, and livable neighborhoods while others remain unproductive, serving low-density single-family housing for decades. For the investment in the transit service to provide the best return on the public's dollar, the factors that make TOD-supporting station areas must be better understood. This paper attempts to isolate those key factors with a mixed-methods approach to understanding what makes light rail station areas successful in supporting TOD, and what barriers might exist to encouraging development near other station sites. In short, what makes a station area succeed? We chose to focus this study on the light rail network of Dallas, Texas – the nation's largest light rail system by route miles.

This research is in two parts. After examining the literature to find what is already known about TOD, station-areas studies, and Dallas-background, I then conducted a descriptive analysis using Dallas as an example. Dallas is home to the nation's longest light rail network and has operated its earliest lines from 1996. I attempted to illustrate the disparity in development near Dallas light rail stations quantifiably, using land value data of parcels near light rail stations. From these observations, we can inform the next stop of the research.

The second analysis was an open-ended interview with several planning policy and development experts from around the Dallas area. Through an expository discussion, I sought their opinion on why development was so concentrated near only a few light rail stations and tried to learn more about the development and planning process for making successful TOD. Their answers helped to inform a final analysis; a quantitative Structural Equation Model (SEM) used additional data to glean what makes station areas successful at attracting transit-oriented development.

The model we developed explains 77.4% of the variation in DART light rail station area property values, and our trial-and-error process of achieving a model where all variables are statistically significant helped us to test several hypotheses about what makes station-areas more highly valuable than others. In short, we could explain the variation in station-area property values using the latent, or intermediate variables of Residential & Commercial Floor Area Ratio (FAR), combined with the frequency of rail service. Inside the latent FAR variables, variation could be explained by several demographic and land use variables. Despite having a large pool of datum to choose from to include in the data, the variables that were not significant were as important as those that were. We were able to show through the data that several ideas about development near rail stations in Dallas could be challenged.

Chapter 2 - Literature Review

The interaction between public transit and land use has been studied for decades. Henry George (1879) laid the foundation for our understanding of urban real estate markets during the industrial revolution. While George's work primarily addresses urban poverty and labor productivity, he outlines how building urban communities creates value. This concept is fundamental to current transit-oriented development understanding, where increased transportation services led to higher land values in the community.

Puškarev & Zupan (1977) were the first to specifically link any transportation service, be it highways or public transit, to real estate values. While George didn't explicitly mention transportation service, Puškarev & Zupan documented the close relationship between transportation service and real estate values, calling these areas transit-supportive zones. They focused on prewar streetcar suburbs as having the greatest ability to support public transportation financially. Still, they also noted that newer high-density areas would make increased public transportation service economically viable. Their model identified various residential land use densities and their corresponding linkage to a high-employment central business district to guide transit service levels.

Transit-Oriented Development

Many studies have explored the concept of Transit-Oriented Development (TOD), which emphasizes creating compact, mixed-use communities around transit stations. Authors like Cervero (Cervero, 1998), Calthorpe (1993), and Newman and Kenworthy (1989) discuss how TOD can influence land use patterns, promoting higher-density developments and a shift towards more sustainable modes of transportation. The literature is often focused on specific transit projects and their impact on land use in the cities in which they are built. For example, Giuliano

and Small (1991) investigated the relationship between the Los Angeles Metrorail and changes in land use patterns near stations. They identified the presence of rail transit led to substantially increased residential and commercial development in station areas. Over time, the phenomenon of more intensive land use near rail and other high-quality transit has become better understood and expected because of the construction of new systems.

Station-level studies

While researchers look at many land-use variables when discussing TOD, the most common variable to measure the economic impacts for rail projects used are property values. The percent rise of property values in neighborhoods served by transit is popular presumably because it can test the idea that the transit service is a valued service. This hypothesis has been tested by the works of Cervero (2004), Arrington (2004), Weinstein & Clower (1999), Ewing et al., (2011), and Garrett (2004), among several others. Weinstein & Clower have evaluated this relationship in the Dallas-area specifically and found several billions of dollars of new value that can be attributed to the construction of DART light rail.

While the network or rail-systemwide value add of has been studied by many authors, few researchers have studied the relationship at the rail-station level. The work of Rachel Weinberger (2001) used a station level-approach to study the relationship each Santa Clara County light rail station had on its neighborhood. Weinberger used property values and rental occupancy rates, among several other variables, to determine what effect, if any, the VTA light rail service had. At a ½-mile radius from the station, Weinberger concluded that properties in a station area commanded higher lease rates than other properties in the county. She could also conclude that the benefit of the network improved over time, however the positive impacts of the rail service waned in times of other market pressures. Weinberger's approach to station-area

research was very helpful in the research design of this work, however her work fell short of helping to answer the question of why development prefers one station over another.

The work of Julie Cooper (2014) looked at four stations along the newest portion of Chicago's Orange Line heavy-rail transit, and the neighborhood-level impacts that stations had on the surrounding neighborhood. Cooper was not concerned with the property-value rise from transit, rather the value-gained and increased economic activity from connecting the neighborhood to jobs via transit around Chicago. However, her station-area research included several useful neighborhood characteristic variables such as household income, spending habits, housing density and housing type. Also, the impact of vacant properties on the station neighborhoods.

Chapter 3 - Background

Transit-Oriented Development in Dallas

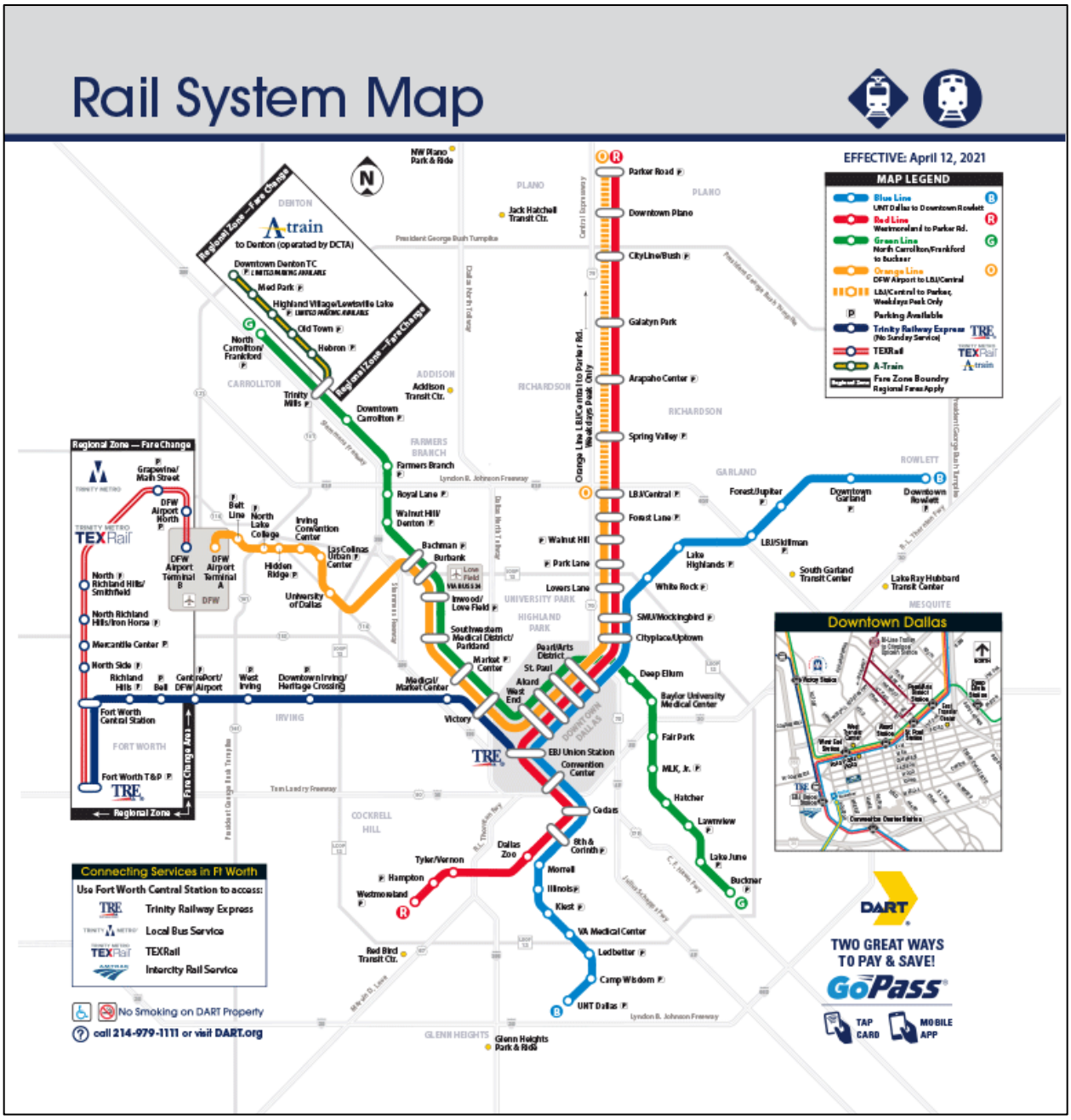

Figure 3-1 - System map of DART Rail Services, including connecting rail services to Fort Worth and Denton that are not operated by DART.

DART was established through a regional referendum in April 1983. While initially it took over the operation of the city's bus system and expanded it into a regional network, the

establishment of DART was all about rail. Inspired by cities like Atlanta and San Francisco which were embarking on large heavy rail projects, DART's boosters envisioned a similar kind of network linking all of North Texas (Benning, 2013). The initial plan for DART was for more than 160 miles of heavy rail, funded by a regional sales tax. However, the plan was too expensive for constituents of several cities in the Dallas metroplex, and the plan for regional heavy rail had to be pared back. This was when the idea for light rail, a cheaper and more flexible alternative to subways, was conceived for Dallas.

Today, DART operates seven light rail lines and partners with Fort Worth on a commuter rail link between the two cities. The light rail lines radiate out from Downtown Dallas and are organized into four colored routes which interline through the city center. The first routes to open were the Red and Blue lines in 1996. Extensions on both routes opened in 2001-2002, linking Downtown Dallas and Plano. In 2006, federal funding enabled the doubling of the network's route miles through the construction of the Orange and Green Lines, which opened in 2013 (*DART.Org - Orange Line Facts*, 2021) . An extension to the Dallas / Fort Worth Airport opened in 2014. The last system expansion to open were two stations on the southern end of the Blue Line in 2016 to UNT Dallas.

DART light rail trains run seven days a week, from 4:30 AM until 12:30 AM. Each line maintains 15-minute headways most of the day, which drop to 20 and 30 minutes during the late night. Since most of the system shares tracks with at least one other line, the frequencies in these sections are higher (*DART.Org - DART Schedules*, 2021).

Economic Impacts Studies

DART regularly commissions updates to an ongoing study of the economic impacts that light rail has on the surrounding neighborhoods. The latest update conducted by University of

North Texas Economist Michael Carroll and his team, concluded in May 2020 (Carroll et al., 2020). Their study concluded that indeed the light rail network continued to have a significant direct impact on the makeup of the communities surrounding it: 81 developments within ¼ mile of a DART light rail station with property values of more than $5 billion. This broke down into 2.123 billion for commercial space, $2.068 billion for residential projects, and $947 million for mixed-used projects. They also surveyed lease rates to check if light-rail served stations were commanding a rent premium, where they found that residential units within a ½ mile radius of light rail stations commanded a 17.9% rent premium, commercial spaces a 23% premium, and office spaces a 5.8% premium.

1999 UNT Study

The 2020 update to the research was not the first of these studies. Previous research by various teams at the University of North Texas (UNT) studied light rail's impact on the built environment almost since the line opened. The first study by researchers Bernard Weinstein and Terry Clower attempted to study the initial impacts to the real estate market after the first phase of the DART rail network opened in 1996 (Weinstein & Clower, 1999). At that time, the relationship between rail transit and property values was not nearly as well understood or researched. The data that Weinstein and Clower had available suggested that there was **not** a consistent relationship between property values and transit, as suggested by data coming from Atlanta, the San Francisco Bay Area, Washington DC, and Toronto. Beginning this study, they recognized that Dallas' extensive built-out highway network and decentralized urban space would pose a challenge to light rail's ability to attract development there.

In 1994 when this longitudinal study began, the real estate market in Dallas was recovering from a 1980s era recession, but prices everywhere were on the rise. To test the impact

of light rail on property valuations that were rising everywhere, Weinstein and Clower sampled properties near light rail and several control neighborhoods that had similar characteristics to those near light rail but were not served by DART rail. Between 1994 and 1998, total property values were about 25 percent higher near light rail stations than in the control neighborhoods, with only a few exceptions near the Illinois and Westmoreland stations. The researchers observed that these stations may have had light rail construction related impacts and relocations which may have lowered property values there. They concluded that "while not true for every class of property in every neighborhood, the proportionately higher rise in values for DART-served properties suggests that the light rail system is having a positive economic impact." This finding went on to be cited by many other researchers as part of the growing body of research indicating light rail bolstered property values where it is built. The study found that the Mockingbird / Cityplace / Lovers Lane corridor northeast of Downtown Dallas had the most significant gains systemwide.

Weinstein & Clower's study had interesting conclusions on the impacts to commercial properties and office buildings. In the commercial market, they saw occupancy rates within a ½ mile radius from new light rail stations jump more than 8 points from 1994 to 1998, and rents at those properties increase a staggering 47.4 percent at the same time. Retail properties were more difficult to study due to changing national trends, however they noted that the one mall served by DART remained 100% occupied and rents rose by 27.4 percent. Strip malls and industrial properties near light rail also experienced significant gains in occupancy and rental rates.

Besides looking at the raw real estate data, Weinstein & Clower interviewed the real estate and development community to gauge their interest in development near light rail stations. They asked brokers, managers, leasing agents, and developers a series of questions in six general

topics and gauged their knowledge of how light rail was influencing real estate in Dallas. Their interviews suggested that developers were already excited about pursuing sites near light rail over non-DART adjacent properties. Summarized, they said that DART rail was "a critical factor in Dallas' long-term growth because of growing traffic congestion and air pollution, especially near downtown." Brokers and tenant representatives who were interviewed responded that they were seeing more prospective tenants were asking to be shown homes near DART stations and noted while it may not be the critical criterion, it is becoming more important for tenants as traffic congestion gets worse and car parking rates increase around the city.

Several of the developers responded that DART should acquire more land and establish a master planning system for development near light rail stations, especially in South Dallas. Many voiced their support for a City of Dallas – sponsored redevelopment agency that could help spur revitalization in the downtown core and surrounding neighborhoods by coordinating between developers and the city. Generally, many respondents said that more coordination was needed between DART, the City of Dallas, and developers. Some respondents said that the DART network was too limited and needed to be expanded before it was useful to more potential residents of DART-adjacent developments.

2002 Update and 2005 Station-Area Development Study

Weinstein and Clower (2002) re-examined the impact of having a DART light rail station within one-quarter mile on property values using a slightly different methodology. They found that between 1997 and 2001, median values of residential properties increased 32.1 percent near the LRT stations compared to 19.5 percent in the control group areas. For office buildings, the increase was 24.7 percent for the DART properties versus 11.5 percent for the non-DART

properties. There was no impact on retail properties and a negative impact for industrial properties.

In 2005, a decade after DART rail service began, DART commissioned Weinstein and Clower again to update their research into DART's economic impacts (Weinstein & Clower, 2005). Instead of looking at non-DART rail served properties versus properties adjacent to DART stations, this study attempted to estimate the total value of new investment completed, under construction, or planned near stations. Importantly, they noted that this study did not suggest that DART rail service was the only factor driving investment decisions, but rather it showed the sheer value of new developments that was heading near DART-served stations. They searched through published articles in local newspapers to find news on new developments that were happening around the region, the address of the development, and the closest DART station. Using the valuation of the projects reported by the newspapers, they identified $3.3 billion in new development that was heading to DART rail station areas. They then were able to summarize this list of developments by station and found the Park Lane, Las Colinas, Mockingbird, and Downtown Plano stations to have the highest amounts of reported new developments.

2007 UNT Study

In 2007, DART commissioned yet another update to the original 1999 study (Clower et al., 2007). This time, instead of simply cataloging the development built, under construction, or planned for light rail station areas, the team attempted to assign a value that was attributable to the presence of a DART rail station. Like the 2005 study, this update used the "announced value" of developments near DART rail stations found in newspapers but took the study a few steps further to ensure that no developments were missed and to ascertain if developments were

attributable to the proximity to a DART rail station. The team used aerial photography, interviews with local and regional planning staff, and on the ground observations to categorize each development. The primary goal of this research was to analyze the economic impacts to local tax rolls, so properties were categorized based on their potential new property tax or sales tax revenue (or lack thereof, for public buildings). Based on this more detailed and nuanced approach to measuring transit-oriented development near stations, Weinstein & Clower were able to find that $4.26 billion in new developments were attributable to their proximity to DART Rail, meaning they would not have been built otherwise. They also found that the new developments would generate more than $660 million in annual taxable retail sales and return $6.6 million in annual municipal property tax receipts. The study summarized that transit-oriented development was still growing significantly near DART rail and continued to have a significant positive economic impact for the communities that were served by rail.

The UNT Economic Impacts Studies are ongoing, and its authors have published several additional updates in 2012. 2015, 2017 and 2020. These studies continue to indicate a preference for development and property value increase near DART rail stations.

Chapter 4 - Methodology

This research used several research methods, quantitative and qualitative, with each step informing the next. The first step is a descriptive analysis to explore the relationship between real estate values and light rail station areas. This basic quantitative approach simply analyzed parcel values per square foot for all parcels within a light rail station service area. This data helps describe the situation in concrete dollar values and formed the basis for a *descriptive analysis* of DART station areas.

The data helped form questions that I then asked of local Dallas planners and developers. This qualitative approach helps to bring more nuance and understanding of the process and also raised several additional questions about the distribution of TOD that could be tested with additional data analysis. Respondents to e-mail surveys were then interviewed via Zoom meeting or phone call for an informal conversation about TOD production near light rail stations in Dallas and their personal experiences with the site selection and distribution of new sites.

Finally, we combined all the known data into a *Structural Equation Model (SEM)* that would help to isolate variables that make a station area better or worse at attracting TOD. At each step, I'll discuss the specific data sources and procedures I used to achieve the results.

Chapter 5 - Descriptive Analysis

In the effort to find what makes a station area successful at attracting TOD, we have to first make a few assumptions. First, what is a station area? What data is available? What are the right questions to be asking? To help inform this first phase of the research, I sought out to complete this first descriptive analysis. The literature revealed the independent, or explanatory variable, would be property values near light rail stations. Property value is a good indicator of developable interest in a property. There are factors at high value properties which make them valuable and other factors at low value properties that make them less valuable. The one thing that all the areas in our study have in common is they are served by the light rail network. What does that mean?

Station Area Definition

Many researchers have used various metrics to define what the service catchment area of a station is. The various UNT study assumes a ¼ mile simple radius from the site of the station as the service area. They chose this metric because ¼ mile is typically how far someone will have a convenient walk to the station site. However, reviewing the land around Dallas light rail stations shows that in station areas cited by those studies as successful, like the Mockingbird or Downtown Plano stations, for example, high-intensity development was occurring further than ¼ mile. The Transportation Research Board's *Transportation Capacity and Quality of Service Manual* (2013) suggests a ½ mile radius from the station as a better measure of how to capture land use near station areas. The manual suggests that a significant number of residents who live within a ½ mile radius of high-quality transit are willing to use it, although beyond the ½ mile boundary that number drops off precipitously.

Other methods involve doing a walking-distance analysis of areas that are a certain number of minutes' walk from a station point. We considered this analysis but found that the analytics of comparing station areas between each other based on what was built up around them would be difficult to do with a path-based system. Also, since we plan to use multiple kinds of data layers, this analysis would bring more complexity than it added sound data.

Furthermore, there are many things which exist in space near a light rail station. We need to pick the right analytical tools to capture them. Property value, our independent variable, is captured by parcels. In Texas, parcels and tax assessments are collected by a county assessor's office and change from year to year. We used the most recently available data for both study counties, Dallas and Collin. Both had 2020 data available. However, property boundaries do not conform to a neat ½ mile circle around a station! A simple intersection of parcels near light rail showed broad variety in how different the sizes were from one to another. So, we needed a way to compare stations between each other when they are irregularly sized and comprised of irregularly shaped pieces. Also, with station's catchment areas overlapping in some places, we needed a way to attribute qualities from the overlapping zones to all stations there.

First, we downloaded the parcel land value data from both Collin and Dallas Counties. Then, we removed the parcels that did not touch the light rail service area boundary. Finally, we did an "intersect" cartographic transformation. The intersect function creates individual parcel "pieces" for each portion of a parcel within a given station area. This means pieces that fell within two station areas were duplicated, one piece for each station. Since the original value and geometry of the parcel were retained in the parcel's attribute data, the percentage of each piece of the parcel that was included in each station area could be found by dividing the new piece size from the original parcel size. This created a "percent area included" metric that let us perform the

station-area analysis. A similar intersection analysis was created for US Census Block Groups to get representative amounts of sample demographic information. With the "percent area included" metric, variables like the parcel value, land use type, and demographic information could be multiplied by it to find the approximate value for the individual piece of the station area.

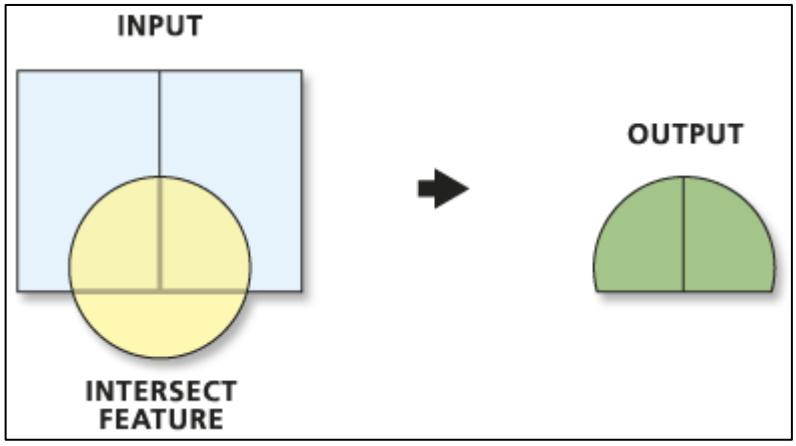

Figure 5-1 illustrates how the Intersect tool can help analyze polygons that fall on the border of a station service zone. (*Intersect (Analysis)—ArcGIS Pro | Documentation*, n.d.)

Light Rail vs. Other Rail or High-Frequency Transit

DART operates the longest light rail network in the country. The DART system spans 64 stations, serves four counties, and has 104 miles of double track, electrified rail lines. However, this is not the only high-quality rail service present in the DFW metro. DART and neighboring Fort Worth transit agency operate the Trinity Railway Express (TRE) between the downtowns of Dallas and Fort Worth. This is a full size, diesel commuter train and has regular, hourly service along the line with a 30-minute frequency around the rush hour. There is a reduced service on Saturdays and no Sunday service. While this is a great transit service for the region, it is too infrequent and does not meet the literature's definition of light rail because of the limited-service span and lack of Sunday service.

Two other commuter rail lines exist in the DFW area. First is a rail line that runs from downtown Denton, a suburb North of Fort Worth, to the Downtown Carrollton light rail station on the DART Green Line. The other is the new Fort Worth TexRail line from the Dallas / Fort Worth Airport to Downtown Fort Worth. Like with the TRE, these services do not meet the literature's definition of a light rail line because of its limited-service span and frequency. The TEXRail approaches light rail frequency, but never hare more than 3 trains per hour. However, there are several new developments happening near these lines that were referenced by the latest UNT update. Additional research into TOD near commuter rail lines in Dallas would be another interesting topic.

Finally, the McKinney Avenue Streetcar and Oak Cliff streetcars are rail services run near Downtown Dallas. These services fulfill local transportation needs in the central business district and out towards DART's Mockingbird Station. The McKinney Avenue Streetcar has significant new development happening nearby and uses a fleet of restored historic streetcars to move people through the neighborhood. The Oak Cliff streetcar serves a different area and uses a hybrid battery-electric vehicle. DART operates a growing network of frequent bus services after a 2018 system reimagining by transportation consultant Jarret Walker. However, the data does not suggest currently that these kinds of transportation significantly attract new development.

Omitted Stations

In Texas, the job of property assessments is by county. Dallas County and Collin County, just north of Dallas, make this data easily available for use. While it is not the same, the datasets published by the two counties are similar enough that they can be summarized and compared together. The third county that DART light rail serves is Denton County. The Denton County Appraisal District does make property values available, but they are not available as a single

dataset to be easily incorporated into the model. Furthermore, there is only one station at the very end of the DART Green Line that extends into Denton County. For these challenges, the North Carrollton / Frankford Station was eliminated from the analysis.

Likewise, the DFW Airport station, the terminus of DART's Orange Line, was not considered. There are no other land uses adjacent to the airport to be easily redeveloped into TOD. The station is surrounded by the airport and the highway serving the airport. This station was eliminated from the analysis.

Central Business District

The Dallas Central Business District (CBD) is an interesting case. The DART light rail network serves several suburban downtown stations, but the Dallas CBD has extraordinarily high land values which make comparing to other areas difficult. Furthermore, while the CBD certainly has benefitted from the construction of light rail service there, it is not fair to say that the light rail has caused the boom in downtown real estate or that the high values downtown are just because of the rail service. The UNT researchers made the decision not to include downtown stations in their analysis, so we decided to follow suit.

In total, there were 54 stations in the analysis. To find the explanatory variable and begin a more complex data analysis, we calculated the value of the station area per square foot.

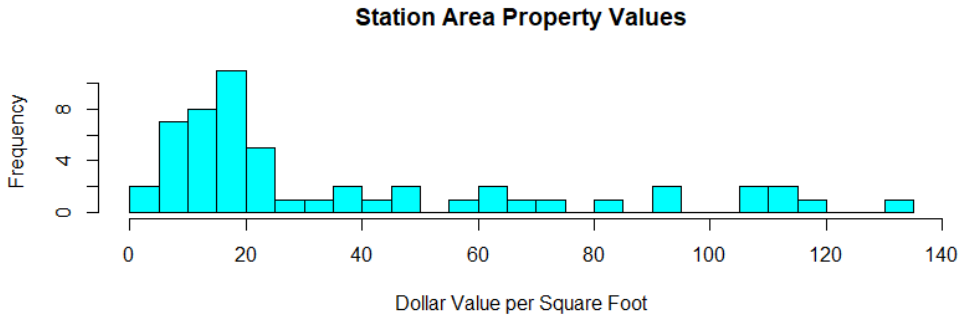

Figure 5-2 shows the distribution of station-area values per square foot.

Independent Variable – Property Value per Square Foot

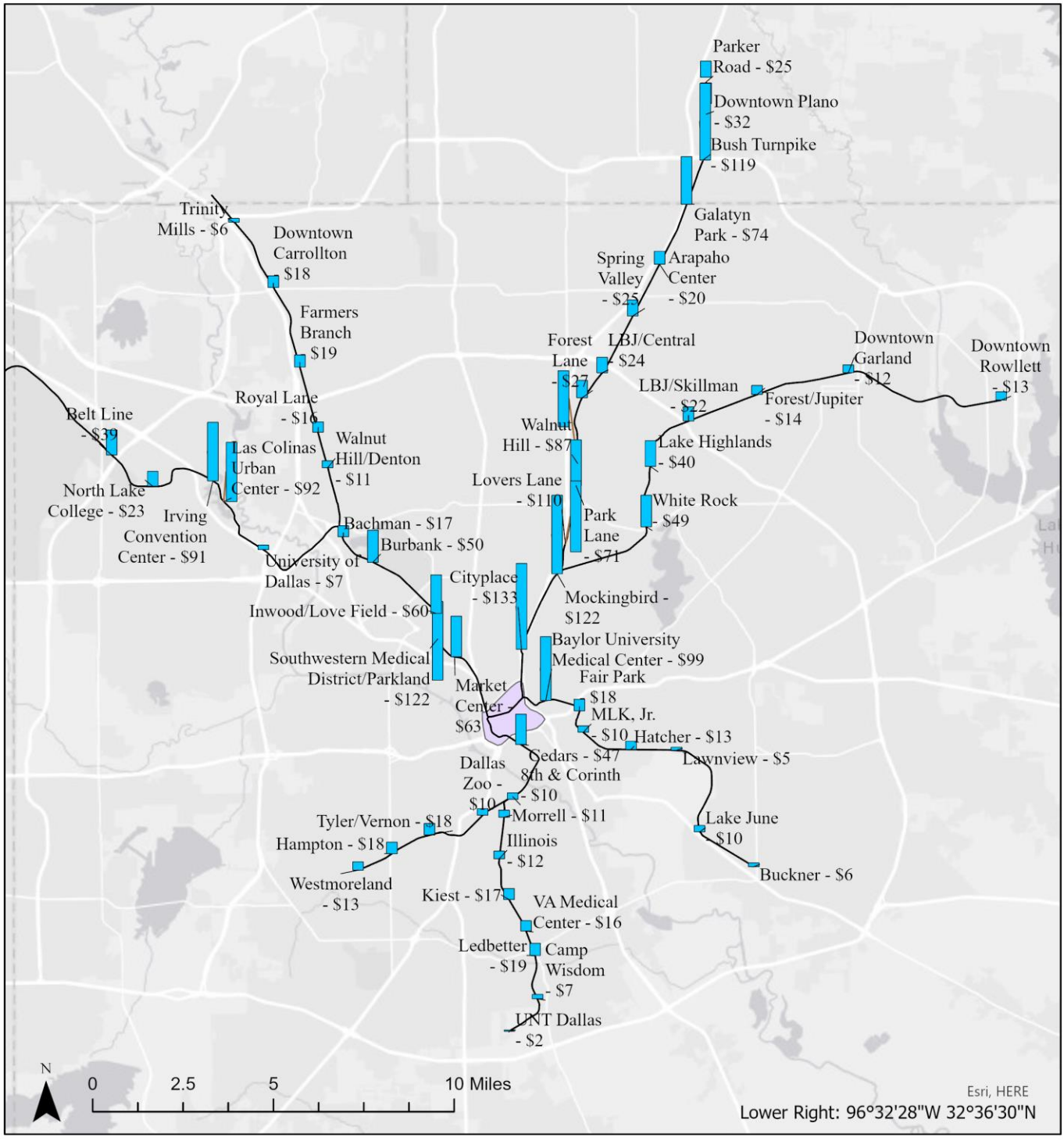

Figure 5-3 - Map showing property values per square foot aggregated over 1/2-mile radius from studied light rail stations.

Initial Observations

This data and map confirm a geographic disparity with real estate values around the DART network. This alone is unsurprising, as real estate markets are highly varied in most cities. The map does show a clear North / South divide, which roughly follows historic racial and socioeconomic boundaries.

However, what is surprising is the concentration of high value near a certain few stations. Through additional analysis, we want to find out what exactly makes them successful at attracting and supporting that value, and if anything might be done to replicate that success at other light rail stations in the area.

Of the high value stations that we identified in the above results, several are mentioned in the UNT studies as having successfully attracted billions in new real estate investment near their locations. Secondly, there are many other stations with very low values. Some as low as $2 per square foot at the UNT Dallas Station, or $5 at Lawnview. Again, these stations tend to be in South Dallas. The higher value stations tend to be in North Dallas, though there is much diversity in those station values as well and not one conclusion can be drawn for any one of them.

These initial observations helped to guide our research process. We asked ourselves, what makes a station site successful at driving high value properties? Why is value so concentrated near those specific stations and not around other stations in South Dallas or other suburbs? After making these initial observations from the data, it was time to use this information to inform the next phase of the research where we asked planning & development experts.

Chapter 6 - Ask the Experts!

From the descriptive analysis, we can make lots of observations about how real estate values are distributed around light rail stations. However, this is just a surface-level analysis. For better understanding about the how and why the station areas are valued as they are, we asked real people with development, research, and planning experience near the light rail network in Dallas. This phase of the research takes inspiration from the earlier work of Weinstein & Clower, which surveyed attitudes of developers to check their response to light rail development in Dallas. In that respect, these were only semi-structured interviews. Since I personally do not have much firsthand planning and development experience, I also used the interviews to learn more about how the process works from the perspectives of the participants I talked to. This knowledge also helps inform the research into how TOD sites are selected for development.

Because this was considered research on human subjects, I sought Kansas State University Institutional Review Board (IRB) approval before contacting the participants. The IRB process identified the research as human subjects: exempt. The IRB interview protocol and approval letter from the K-State IRB is included in the Appendix A.

Interviews were conducted via Zoom or telephone call in spring – summer 2020. While I stayed closed to original questions outlined in the proposed interview protocol, the interviews turned into several long, in-depth conversations about the development processes in each respondent's area of expertise. I have chosen to present the findings of these interviews as a summary by key development issues and will use direct quotes from the experts themselves where necessary to illustrate their points.

Beyond providing knowledge on the challenges and successes Dallas has had developing near transit lines, the interviews also raised several points on the nature of DART TOD sites that could be tested in the next analysis phase.

Interview Subject	Association & Role	Key Points
Developer	Urban Land Institute, Principal at Dallas-based Development & Investment Firm	"Housing markets are supplying what can be supported by the local market."
DART Planner	DART Economic Development	"DARTs leads TOD site selection and packaging station area sites for TOD."
Planner for Local City	City of Plano	"Community buy-in and development essential for Downtown Plano TOD success."
Researcher	Economics, University of North Texas	"Updates to regular TOD studies continue to show strong success and regional support for TOD."

Market Absorption

I interviewed a developer with extensive knowledge and experience developing high-quality TOD properties near light rail stations. They identified many issues around why development near light rail stations isn't spread equally – it is because it is designed that way. One of the compelling arguments they made for that conclusion was regarding the ability of the real estate market to support all the new apartment units. Their team spends a lot of time and resources trying to understand just how many new rental units can be "absorbed" by the market and understand where the market for housing will be in a few years.

"A considerable number of new developments are happening within light rail station areas compared to the whole market. The land area is a very small percentage of the entire region, but those areas are really capturing more than you might expect in new development. That is evidence that being near transit is driving decisions to develop on sites or not," the developer said.

However, they said that developers and planners shouldn't be too aggressive in trying to develop out all the station areas at once. They noted that a lot of the TOD projects being built in Dallas are massive and can cost hundreds of millions of dollars and years of time to build. North Texas has a vibrant economy, but they already had known of several projects built adjacent to rail that were struggling to maintain occupancies. They said they had looked only at numbers from a recent headquarters move to the region and had not planned on just how many housing units would be needed.

"It's a real balancing act to think long-term, like 2-5 years out. Sometimes it's better than you thought and sometimes it is worse, but development always has its risks. Where will the demand be when your project gets finished? Everyone has to aim for the right absorption targets for these developments to be successful."

The spokesperson for DART agreed with the developer's sentiments on market absorption, saying that DART can put parcels out to bid for developers to build on, but in the early days, nobody was bidding on it. Now, as more station areas are becoming built out, large parcels that were once available to be developed are not available, and developers are having to be more creative. "I always am working at tempering the high expectations of the DART board," the DART planner said.

Station Build-Out

The success of existing TODs also plays into this complex equation. Developers do not want to build out a new station site when there is available space in a station area that is already being developed. Prospective tenants want high-activity vibrant neighborhoods. If new development is located at an isolated station with no other amenities, it wouldn't be successful.

Developers are filling out in-demand station areas first before moving on to the next big thing. These sentiments were echoed by several interview participants.

Transit Network & Structural Issues - "Is the network ideal or functional for TOD residents?

Another issue consistently raised was the utility of the public transportation network to get people where they really want to go. While all parties recognize the value added to parcels near transit, a common issue was that rail could not replace many of the trips Dallas metro residents must regularly make. The developer I spoke with seemed to indicate that parking availability and highway access were still key amenities for tenants, and that successful TODs were located near both highways and transit. Furthermore, they stressed that while the transit network was great at serving downtown destinations, somehow in its expanse it avoids serving any of the shopping malls anywhere in Dallas. "The (end of the Red line) Parker Road Station gets around 3000 riders per day while the highway often moves 300,000. The rail service is only picking up a small segment of users – its helping for sure, but it needs to go to more destinations before it's effective to live in Dallas without a car," the city planner said.

Socioeconomic Issues

I specifically asked about development challenges in South Dallas near-downtown stations, like the Cedars area. Everyone that I interviewed indicated that the area was just not a very nice place to live, and therefore not as conducive to supporting developments. However, some new developments are happening on the periphery.

"It's homelessness and old legacy racial tensions that Dallas cannot seem to give up," the developer said. "I really want these places to work, but anything south of I-30 have issues that stem all the way back to Redlining. South Dallas has never overcome that."

Economic growth has come slowly to these neighborhoods, however projects near the VA Medical Center and new public housing projects are helping to slowly rejuvenate the area.

TOD Knowledge Gap

Despite all the progress that Dallas has made in the past two decades, one of the issues consistently brought up was the lack of knowledge about the value-add near transit, especially light rail, among the development community. For DART and the UNT researcher I talked too, that was a primary reason to continue their partnership in continually updating the study on the success of developments near light rail. The more it is known how much value the light rail system is attracting to it; the more station sites can be developed in lieu of greenfield sites.

Station-Area Plans

DART is interested in developing TOD along its corridor, and coordinates with developers by packaging parcels that DART owns into a station development plan. These plans are led by DART to facilitate as much high-quality development as possible and include funding sources through HUD that are not available to other private -market developers.

In 2019, DART completed a property inventory evaluating remaining DART-owned properties near light rail stations. In several stations, they found large, underutilized parking lots near stations which already support TOD. Using a data model, they ranked each station by its ability to support new TOD, and are working on plans to divest these properties for expanded development. In these cases, DART will work with developers on creating new TODs and will help in the planning and zoning change processes.

Long-Range Planning

The Downtown Plano redevelopment is often cited in the literature as one of the most successful TODs in the Dallas region. The success of the redevelopment is rooted in the long-

term planning process. Planning for the project began in the 1980s, where the community envisioned a reinvigorated downtown after most of the businesses moved away. This led to the creation of a multi-use zoning district, the first one in Texas, that was incorporated into the long-range plan. The city purposely renovated their office space in Downtown to serve as an activity center and anchor for offices and retail instead of moving City Hall to a new site. However, having a willing and flexible development partner also made a big difference. The TOD in Downtown Plano was a first for a Texas suburb, so the city worked with local developers who understood the vision for the project and were somewhat more flexible with trying something new. The first phase of multifamily and commercial space was built, and the area quickly gained a critical mass and snowballed into more and more good development.

Summary

- The Dallas-area real-estate market can only absorb so many new high-density, TOD units. Several large projects were built to coincide with a new anchor, like State Farm Insurance or Texas Instruments. Sometimes they are part of a Master Plan, like Plano.
- Developers must be disciplined in where they develop new units and choose to develop near existing successful TOD until that station area is built out. Its easier to build on existing successes rather than build the kind of density and energy necessary for success from scratch.
- The Transit network can't get everyone, everywhere – so TOD residents still desire highway access and ample parking. They may use transit for some trips, but vehicle ownership is still a necessity in Dallas.
- Socioeconomic issues like homelessness and crime scare off developers and investors in some parts of South Dallas, preventing these areas from realizing their potential for TOD. Some projects are attempting to address this stigma and underlying issues, but development will still avoid these areas until those problems are resolved and new residents can feel secure living nearby.

- Many of the successful TODs in Dallas are the result of DART or city-led master plans. There are some examples of ‘emergent’ TOD, however these are not as large or as productive as master planned efforts. The stations that lack TOD are simply stations that have not had the master plan completed or nearby DART-owned parcels packaged for development yet.
- Some developers may not yet be aware of the market preference and high performance of TODs, which is why DART continues to fund research on its successes.

Chapter 7 - SEM & Quantitative Analysis

Taking what we learned from the interview process, we sought out to learn more about the DART station areas through exploring more data. We first explored using a Hedonic Price Model but found that a more robust method was necessary. Structural Equation Modelling is useful because it can show how observed variables influence independent variables through latent or intermediate variables (Kline, 2016). Since there are many variables that influence land development and value, we found through trial and error that the SEM approach better fit the available data than trying to isolate specific variables using alternative methods like a Hedonic Price Model.

Big Picture Overview

The objective of this phase of research was to narrow down those features of a light rail station or station area that are successful at supporting or attracting TOD. To do that, we needed as much data as possible to help describe the station or station area. We reviewed several previous studies on transit-oriented development, which looked at environmental, socioeconomic, and physical factors to describe station areas and simply tried to build a dataset that had as much information about each station area in it as possible.

Then, we used several modelling and data transformation techniques to help use the data to describe our independent variable: Property value per square foot. Based on the interviews and observations made in the descriptive analysis, we formed several hypotheses we wanted to test using this larger dataset. In short, by asking lots of questions informed by the interviews and the earlier works, we could see if the manipulation of the model by the inclusion or exclusion of factors would yield any significance.

Specifically, we wanted to ask the following questions of the data to see if these factors were significant in predicting the value and TOD success of a station area.

- Is the neighborhood racial or socioeconomic status a significant factor?
- Is nearby highway access a significant factor?
- Are the policies of individual jurisdictions, like the City of Dallas or the City of Plano, a significant factor?
- Does the quality or frequency of the transit service make a difference?
- Is the amount or presence of park & ride parking significant?
- Are TODs more successful if they are closer to downtown?
- Does single-family zoning or land use impact TOD production?

Essentially, we cobbled together a large dataset with as much information as we could find, and then constructed the best model we could that might explain the variation in real estate values between stations. The resulting significant factors and their residuals would help us answer these questions. Either the interview participants or earlier researchers had suggested these layers are significant, but we can test that by explaining the variation through data modelling.

Data Layers & Sources

To create this larger expanded dataset, we used a variety of data types and sources. There is no easy, one-stop-shop for data that can describe the granular neighborhoods near light rail stations, so we had to build the best one we could from the most recent available data. Each area has its own unique attributes, and we did our best to ensure the data we captured best matches the neighborhood served by the stations. Those sources and the level we captured at are in the following table.

Data Type	Level	Date	Source
DART station sites	Points	2021	DART
American Community Survey 5-year Estimates	Census Block Group	2015-2019	US Census Bureau
Dallas County Parcel Information	Parcel	2020	Dallas Central Appraisal District
Collin County Parcel Information	Parcel	2020	Collin Central Appraisal District
Employer Information	Points	2018	North Central Texas Council of Governments (NCTCOG)
Parking Spaces	Station-level	2021	DART
DART Transit Service	Station-level	Feb 2020	DART (pre-pandemic schedule)
Highway Exits	Points	2021	North Central Texas Council of Governments (NCTCOG)
Violent Crimes	Points	2015	North Central Texas Council of Governments (NCTCOG)

Table 1 - Data levels, sources, and currency for step 3 data modeling

Tools

We used the R Statistical Computing Language to construct the model (R Core Team, 2018). Inside R, we used several common packages to help prepare the data for analysis including tidyr, readxl, ggplot2, dplyr, sf, and plyr. Census data was retrieved using the tidycensus package. The final SEM model was built using the package lavaan and visualized with the package semPlot.

Census Block Group Analysis

The first step in this analysis was to find information on the people who live in the station areas using data from the US Census Bureau. The most granular census data available is at the census block group which is collected through the American Community Survey (U.S. Census Bureau, 2019), which most recently published a 5-year update of Texas data from 2014-2019. Using the tidycensus package, we retrieved block group data from both Collin and Dallas counties. We chose to retrieve ACS data on total population, total households, aggregate income, individuals in poverty, and those with college educations. We also retrieved racial variables for

white, black, Asian, Hispanic, and for two or more races. We made several attempts to include data about foreign born individuals, but after several attempts using several variable calls the data would not come into our dataset using tidycensus.

Since block group boundaries do not necessarily line up nicely with station areas, we needed to appropriate the raw numbers we got from the census into numbers that were attributable to the specific station area. We did this in a similar approach to how the parcel analysis was handled in the first quantitative analysis. We found a percentage of block group land area that was inside a ½ mile radius from the station site and called this new variable "PctArea." In R, we isolated the block groups from the county level dataset that intersected our station sites and multiplied the raw ACS numbers by the PctArea to find an estimate of the amounts of each block group population that was included in each station area. The decimal places for each statistic were rounded to two.

We used an aggregate call to sum the now attributable values to each station site by the station name, using the station data collected during the first quantitative analysis. The next step was to find the percent populations, where we took each ACS variable and divided it amongst the total attributable population to find the percentage living in each station area. This provided two levels of analysis, the percentage and sum, of each ACS variable to test in a later phase.

Additional Parcel Analysis

Station parcel value from the descriptive analysis was carried forward, and additional information about each parcel was collected and prepared for analysis. Both Collin and Dallas counties publish some data about what is built or not built on each parcel but do it in slightly different code systems. Further complicating things, Dallas County publishes data where there can be multiple line items for each parcel account number, which is how we were keeping track

of each unique parcel. To ensure this did not impact our analysis, we parsed the Dallas County residential data for duplicate account numbers and then aggregated the sum of the values for each parcel by the sum.

From the available Dallas County data, we captured whatever we could easily match to a similar Collin County data column. These were data on the gross building area, number of commercial or residential units, and a marker for apartment buildings since these are classified as several different types in Dallas County but not in Collin. The Collin County data was already generalized in a way that was easier to analyze, so after putting each of these variables into R, it was time to combine both county datasets and then reclassify them.

Since this research spans both Dallas and Collin County jurisdictions, finding useful land use data that was uniform across county lines was a challenge. Initially, we used 2015 land use data from the North Central Texas Council of Governments, the regional Metropolitan Planning Organization (MPO). This data was helpful, but grouped blocks of like parcels together and lacked the granularity of the more accurate and up-to-date parcel data available from each county. The solution was to use the land use codes that are included by each county assessor's district for every parcel. Dallas County provides this information separate from their county-level data, but it was easily merged into one dataset for analysis. Collin County includes all the data in one database. These land use codes are informed by a Texas-state level code guideline, however each assessor's district is free to use their own coding structure within that framework based on their specific need. In my case, I needed one general set of land use codes that was uniform between both counties. So, using the state and county resources and data dictionaries as a guide, I informed my own list of land use codes as in Table 2.

Description	Code
Single-family residential	SFR
Multi-family residential	MFR
Commercial	COM
Industrial	IND
Vacant land zoned residential	RVCT
Vacant land zoned commercial	CVCT
Rural, ranchland, and agriculture	RNCH
Government, Parks, Education	GOV
Utilities and other	UTIL

Table 2 – Our list of land use codes generalized from Dallas & Collin Counties. See Appendix B for a full breakdown of which codes got assigned to each category.

After combining the various land use codes into one manageable dataset, we could then sum the areas, attribute by station using the aforementioned "PctArea" field, sum the results and aggregate by station area. We also calculated the percentage of each land use type by station area to better compare the stations.

Station-Level Data

Several data items were achieved at the station level. The first one calculated was distance from each light rail station to Downtown Dallas. We took the station points and calculated the straight-line distance to the old Dallas County Courthouse, now a museum, at 100 S. Houston Street in downtown Dallas. This distance was realized in meters and was checked with the maximum distance being 35,807 meters away from downtown Dallas. We also transformed this statistic by taking its natural logarithm to provide a better basis for data analysis.

Because we were interested in the possibility there were unique policies or approaches that might be evident by city, we coded dummy variables for each city jurisdiction each station site was in. Then, we also coded data on both parking and transit service available at each station. The DART website hosts a station data page with parking information, which was

collected in February 2020. We only included the parking spaces that are owned by DART and included on their website. We coded both the total number of parking spaces as well as a dummy variable for having parking available at the station, since there are several stations with no parking facilities.

One of the more interesting station data points was the train service statistic. We thought that maybe stations with better or more frequent service might be better at supporting TOD. In a pre-pandemic, February 2020 schedule, we simply counted how many revenue service trains stopped at each station every day. Most of the line gets at least a 15-minute service, with some areas dropping to 30-minutes or less in the very early mornings or late a night. However, much of the network is interlined with other lines, doubling or quadrupling service intervals through some portions of the network.

We also downloaded employment and employee points data and a highway exits point dataset from the NCTCOG website. From there, we simply summarized the data with both one mile and a half-mile radius from the station site. We also created an employee density statistic by dividing the total employees by the station area to better compare the stations together. One limitation of the employee database is that it only captures employers with more than 30 employees and does not include small businesses.

Missing crime data

A major disappointment was finding good crime data. The City of Dallas publishes quality crime reports with point locations; however, the city only covers a portion of the DART network. Other police departments do not make such crime data easily available for analysis. There are basic points data for the entire network available for select violent crimes, however

this data was so sporadic that in trying it inside the model, we never found a good way to include it. Crime certainly makes a difference, so this is an opportunity for further research in this area.

Initial trial with Hedonic Price Modelling

In statistics, a hedonic price model is the traditional method for exploring the monetary value that each specific individual variable brings to a product or service, in our case, the land value per square foot of station-area plots. We built and ran several dozen variations of hedonic price models, plugging in combinations of variables guided by Dr. Newmark's experience in studying cities as well as potential insights we had into how the variables might work together in the model. Sometimes, we could yield a model that showed that some of our variables were significant, but others, most importantly Residential and Commercial Floor Area Ratio (FAR). In this case, we realized that most of the variables we were attempting to explain were not impacting or influencing property values specifically, but rather were *passing through* intermediate (or latent) variables, Residential and Commercial FARs, which were markers for development. Essentially, using a latent class analysis can "solve" for development, and in turn, explain variation in real estate values. Those factors that are significant in the variation in development are those that will be significant in the model.

Modeling with SEM

Like our experience with the hedonic model, my experience modelling with the structural equation model (SEM) was a trial-and error process. We knew that Residential and Commercial FAR were extremely significant at explaining the variation in land values, but we wanted to explore the relationships of our other variables working inside or through them. We tried hundreds of variations on this basic premise. Using R, we turned on and turned off variables in

the model until all remaining variables were significant in explaining the variation in land values per square foot. Those factors that are significant in the variation in development are those that will be significant in the model.

The table on the next page shows the various descriptive statistics, and the transformations required to standardize them for data analysis if required. In some cases, the data was transformed using a logarithm to handle skewed data or represent a variable that was most significant as a percentage change.

Descriptive Statistics

Statistic	*N*	*Mean*	*Standard Deviations*	*Min*	*25 Percentile*	*75 Percentile*	*Maximum*
Parking Spaces	62	281.1	359.6	0	0	449.8	2,020
Distance from Downtown	62	13,345.80	9,557.40	333.9	5,139.30	19,275.20	35,823.50
City of Dallas (Dummy)	62	0.7	0.4	0	0	1	1
City of Richardson	62	0.1	0.2	0	0	0	1
City of Farmers Branch	62	0.02	0.1	0	0	0	1
City of Garland	62	0.03	0.2	0	0	0	1
City of Irving	62	0.1	0.3	0	0	0	1
City of Rowlett	62	0.02	0.1	0	0	0	1
City of Carrollton	62	0.03	0.2	0	0	0	1
City of Plano	62	0.03	0.2	0	0	0	1
Frequency of Rail Service	62	203.2	105.8	130	136	257	528
Total Attributable Prop. Value	62	972,818,770.00	1,191,317,560.00	31,680,537.00	222,605,566.00	1,371,869,756.00	4,763,542,152.00
Total Attributable Units	62	1,430.30	2,273.50	0	20.1	1,525.10	9,065
Attributable Commercial Area	62	6,927,887.00	11,169,546.00	87,068.00	1,047,160.00	7,764,908.00	52,480,969.00
Attributable Residential Area	62	2,184,403.00	1,908,478.00	0	792,616.50	2,929,364.00	7,643,315.00
Attributable Developed Area	62	15,275,435.00	2,454,766.00	8,578,246.00	13,971,329.00	16,693,682.00	19,716,876.00
Percent white	62	0.6	0.2	0.2	0.4	0.8	1
Percent two or more races	62	0.02	0.01	0	0.01	0.03	0.1
Percent black	62	0.2	0.2	0.01	0.1	0.3	0.8
Percent Asian	62	0.1	0.1	0	0.003	0.1	1
Percent Hispanic	62	0.4	0.2	0.03	0.1	0.5	0.9
Total station incomes	62	242,244.50	286,055.60	27,529	66,055.20	239,059.50	1,099,341
Total white population	62	2,079.30	1,412.90	25.5	1,043.80	3,082.90	6,106.70
Total black pop	62	733.6	667.6	8.2	212.8	1,020.80	2,770.60
Total two or more races pop	62	68.7	63.7	0	21.9	108	300.6
Total Asian pop	62	214.5	351.3	0	6	299.9	2,382
Total Hispanic pop	62	1,175.30	1,139.00	21.3	422.4	1,711.50	5,412.60
Employers within 1 mile	62	28.9	47	1	5.2	24	198
Employees within 1 mile	62	10,059.30	15,494.90	28	930.2	10,243.50	64,591
Employers within ½ mile	62	9.9	22.6	0	1	7.5	108
Employees within ½ mile	62	3,786.80	7,446.70	0	56.2	3,020.80	34,157
Highway exits within 1 mile	62	6.2	7.6	0	0	6.8	29

Highway exits within ½ mile	62	1.5	2.3	0	0	2	12
Station has exit – 1 mile (D)	62	0.7	0.5	0	0	1	1
Station has exit – ½ mile (D)	62	0.5	0.5	0	0	1	1
Commercial area	62	5,814,028.00	2,835,056.00	969,460.50	3,451,513.00	7,532,543.00	13,775,731.00
Commercial-vacant area	62	2,553,245.00	1,971,268.00	11,063.50	1,312,204.00	3,385,177.00	8,701,073.00
Industrial area	62	242,248.00	420,413.30	0	0	277,316.60	1,830,932.00
Multifamily Residential area	62	1,163,674.00	1,114,094.00	0	249,881.90	1,707,512.00	4,731,949.00
Rural or agricultural area	62	83,655.60	253,790.10	0	0	11,625.90	1,417,361.00
Residential vacant area	62	471,246.00	730,330.80	0	16,259.50	640,866.80	2,981,701.00
Single-family residential area	62	3,078,589.00	3,345,086.00	0	371,147.40	4,895,745.00	13,520,499.00
Utilities – total land use area	62	62,712.90	253,010.30	0	0	0	1,494,674
Independent Variable – Station Value / Sqft.	**62**	**72.2**	**101.3**	**2**	**14**	**89.2**	**418**
Commercial Floor / Area Ratio	62	0.5	1	0.01	0.1	0.5	4.5
Residential Floor/ Area Ratio	62	0.1	0.1	0	0.05	0.2	0.5
Central Business District (D)	62	0.1	0.3	0	0	0	1
Percent commercial area	62	0.4	0.2	0.1	0.2	0.5	0.9
Percent commercial-vacant	62	0.2	0.1	0.001	0.1	0.2	0.5
Percent industrial	62	0.02	0.03	0	0	0.02	0.1
Percent single-family res.	62	0.2	0.2	0	0.02	0.3	0.8
Percent multifamily res.	62	0.1	0.1	0	0.02	0.1	0.3
Percent residential – vacant	62	0.03	0.04	0	0.001	0.03	0.2
Percent utilities or other	62	0.004	0.02	0	0	0	0
Employee density – 1/2 mile	62	0	0.001	0	0	0	0
Value.Sqft.log	62	3.6	1.2	1.1	2.7	4.5	6
ComFAR.log	62	0.3	0.4	0.01	0.1	0.4	1.7
ResFAR.log	62	0.1	0.1	0	0.05	0.2	0.4
Transit Service.log	62	5.2	0.4	4.9	4.9	5.6	6.3
tot.white.log	62	7.3	1	3.3	7	8	8.7
tot.hispanic.log	62	6.6	1.1	3.1	6	7.4	8.6
income.log	62	11.8	1	10.2	11.1	12.4	13.9
EmployeeDens.HalfMile.log	62	0	0.001	0	0	0	0

Table 3 – Descriptive statistics for all variables that were available to use in the final model.

Results

After many iterations and experimentation trying combinations of explanatory variables, we arrived at the following model in Table 4 below. The model says that the station values can be explained by the Commercial & Residential Floor Area Ratios as latent class variables, and the amount of rail service. The latent classes can be explained differently by their type. Commercial development by rail service, neighborhood incomes, employment density, and both actual commercial and vacant commercial land uses. Residential variation can be explained by the amount of white population, Hispanic population, incomes, and both multi-family and vacant residential land uses.

		Estimate	SE	Z-score	P-value	R2
Regressions						
Total Value ($/sq ft)	log					0.774
FAR Commercial	log	2.426	0.401	6.050	0.000	
FAR Residential	log	4.442	0.701	6.341	0.000	
Weekday Rail Frequency	log	0.639	0.231	2.772	0.006	
FAR Commercial	log					0.642
Weekday Rail Frequency	log	0.129	0.048	2.672	0.008	
Household Income	log	0.083	0.021	3.948	0.000	
Employment in station area	log	195.254	71.523	2.730	0.006	
Share Commercial	pct	0.255	0.078	3.281	0.001	
Share Commercial Vacant	pct	0.006	0.124	0.052	0.006	
FAR Residential	log					0.791
White Population	log	0.050	0.012	4.358	0.050	
Hispanic Population	log	-0.025	0.011	-2.255	0.024	
Household Income	log	0.031	0.011	2.292	0.003	
Share Multifamily Residential	pct	0.733	0.088	8.364	0.000	
Share Residential Vacant	pct	0.325	0.135	2.399	0.016	

Table 4 – Best & final Structural Equation Model (SEM) and significant statistics.

This model ran with 16 parameters over 54 station area observations, omitting the downtown Dallas stations. The chi-square test statistic was 80.992 with 17 degrees of freedom and a p-value of 0.00. The standardized root mean square residual (SRMR) was 0.064. Overall, the data fits the model well.

Analysis

This model explains 77.4% of the variation in the Dallas light rail land values per square foot. The model suggests that there is an important relationship between the floor area ratio of both residential and commercial properties and the property value, and that the variation in floor area ratios is a function both higher intensities of those given land use types, station-area household incomes, and several demographic variables.

The fact that properties that were marked as vacant in both commercial and residential FAR showed up as significant is surprising. That means that station areas that had commercial and residential land uses that were now vacant were still improving overall value, which goes against conventional wisdom that vacant properties would bring down value. Perhaps it is that availability of properly zoned or previously developed properties are some things that planners can look for when choosing the next station for a TOD plan.

The most surprising answers in the model were found in what wasn't significant. We spent a lot of time collecting and analyzing data for dozens of variables that were not significant to the overall model. We ran hundreds of versions of both the hedonic price model and the SEM, hoping to glean out any relationships that were suggested by the literature, the interviews, or personal hunches. Below is our list of questions we wanted to test from our interviews with planning & development experts.

- **Is the neighborhood racial or socioeconomic status a significant factor?** We found that yes, when it came to residential development, station areas with higher percentage of white population and higher household income supported high land values, and areas with more Hispanic population reduced it.
- **Is nearby highway access a significant factor?** Surprisingly, we found that no, highway access was not significant or present in high-value stations. This challenges the notion that TODs were only successful because of their access to both rail service and to highways.
- **Are the policies of individual jurisdictions, like the City of Dallas or the City of Plano, a significant factor?** No, city or jurisdiction was not significant. In the models we ran, we tried every possibility to check if the jurisdiction or city played a role in the success of the station area. Especially understanding the TOD-forward policies of Plano & Dallas as evidenced in the interviews. However, no combination of city jurisdictions were significant in the model. We analyzed this very closely.
- **Does the quality or frequency of the transit service make a difference?** Yes, we found that rail service, or more weekday trains, did play a significant role in explaining the overall value of a rail station, and the amount of commercial FAR. Since we omitted the core downtown stations from the analysis where all the rail lines interline with each other, this can help explain the success of high value stations outside of downtown where providing more frequent service can significantly increase property values, as opposed to stations on just one branch that get a service at best every 15 minutes.
- **Is the amount or presence of park & ride parking significant?** No, parking or park-and rides were not significant. This was another variable we looked closely at in the data.

We ran several models where the total number of parking spaces were included, or a version where a dummy variable was included if the station included a park and ride facility, the idea being that nearby land dedicated to parking was hampering the development of TOD nearby. However, despite trying many times to show those variables' significance, they were not significant in the final and best model.

- **Are TODs more successful if they are closer to downtown?** No, the distance downtown from each station was not significant. This was another variable that made sense to us on its face since land values are generally higher in the downtown core. It makes sense that as you get further away from downtown, that land values would fall, and we thought that might be significant in the final model. We chose a point in downtown Dallas, measured the straight-line distance to each station, and tried regressing off that distance to see if that would make a difference in the final model. During some of our hedonic price modelling sessions, Distance would occasionally be significant alongside other variables, however once we switched to the SEM, distance to downtown was not significant any longer.
- **Does single-family zoning or land use impact TOD production?** This was a hunch I shared with our interviewers. To me, it makes sense that TOD might not develop in a station area that already has a high percentage of single-family residential property. However, single-family land use was not significant in our final model. Instead, the share of multi-family housing was a better indicator, alongside residential vacancy. That seems to suggest the inverse, where vacant residential-zoned land are opportunities for developers to build new TOD.

Opportunities for Future Research

There are always opportunities to expand upon this work. We limited the scope of our analysis to DART and Dallas, but it may be that other transit networks or metropolitan areas are better suited for this type of research. Several times, we were hampered by the availability of data across jurisdictions. A larger-scale study of station areas in multiple cities might yield better results for future analysis, or perhaps a smaller-scale study on rail transit in just one city rather than a large metro area with several county and city governments involved in collecting data for analysis.

An obvious omission from this work is the element of time. As our planner and developer suggested in the interviews, there is only so much TOD that can be built or absorbed by the market over time. Construction of the light rail network won't transform the whole metro overnight, and our data was a snapshot of the most recent available data at the time of analysis. So, future researchers could study the propensity of TOD to station areas over a certain timeframe.

Conclusion

Our model provides clear analysis of many factors that impact the variation of property values between station areas in a transit network, the first study of its kind to do so in the transit and development space. This model challenges the "build it and they will come" conventional wisdom about TOD and transit. It simply is not enough to build a new transit line through an area and expect development to follow everywhere. It takes a coordinated approach from planners, developers, and the local community to adopt plans to encourage high density development near light rail stations. The findings reiterate that there are lots of interactions in the housing and development markets that are unseen. While it may be clear that values might

increase near transit relative to other properties, it isn't obvious that that corresponding increase will in turn lead to more development or land use change.

In speaking with the planning and development professionals, I learned there is a long process to developing out station sites already in place, and that it isn't necessarily the housing market that is making decisions about where new development is cited. Because developments are so expensive, the decision to site near transit is easy to make – but only in limited amounts that meter the influx of new multifamily housing stock. Over time, this might lead to substantial changes in how people live in the Dallas metroplex, but for now the demand for single-family homes still outpaces that for multifamily apartments.

Chapter 8 - References

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Appendix A - K-State Institutional Review Board Approval

Subject Recruitment E-Mail & Interview Protocol

To: Institutional Review Board (IRB) K-State

From: Brennan Walter

Date: January 31st 2020

Subject: Subject Recruitment & Interview Protocol for Proposed Graduate Research

Subject Recruitment

Hello, my name is Brennan Walter! I am a graduate student at the Kansas State University in Regional & Community Planning. As part of my graduate research, I am studying land use and development near DART light rail stations. I am interviewing planning and development professionals in the Dallas area about their experience with developing properties near public transportation, or neighborhood stakeholders of organizations near stations. I identified you as a knowledgeable professional or stakeholder in (city) for your work with (agency or company).

I would very much value and appreciate your participation in this interview. If you are willing to participate, please let me know the best time to schedule. I am available:

Monday: 14:00 – 20:00

Tuesday: 14:00 – 18:00

Wednesday: 14:00 – 20:00

Thursday: 08:00 – 20:00

Friday: 08:00 – 20:00

Saturday: 08:00 – 20:00

Sunday: 14:00 – 20:00

If I can help answer any questions before agreeing to interview, please do not hesitate to respond or contact me at any time at brennanw@ksu.edu.

Thanks! I really appreciate your participation!

Interview Protocol

Hello! My name is Brennan Walter, and I am a graduate student researcher at Kansas State University in regional and community planning. I am researching land use and development near DART light rail stations. I am interviewing planning and development professionals about their experience developing properties near light rail, and stakeholders from neighborhood organizations near station sites. The project will be complete in April 2020, and the product will benefit planners to be more informed and make better decisions about planning transportation projects and land use. I identified you as a knowledgeable professional or stakeholder in (city) for your work with (agency or company).

Our conversation should last about thirty minutes. Is this still a good time for our call?

Thanks! I need to inform you that this study is considered research. Your participation is voluntary, you may skip any questions, and you may terminate your participation anytime without penalty. There are no foreseeable risks or discomforts in your participation in this interview. Do you consent to be interviewed? Do you consent to an audio recording to make sure I accurately record your response?

Thanks! We'll get started with the interview. But first, do you have any questions for me?

Questions for developers / real estate.

1. *What is your background in development planning?*
    a. *How long have you worked for (company or agency?)*
    b. *Does your company develop near light rail stations?*
    c. *Why or why not?*
2. *What are some of factors that guide development site selection?*
    a. *Is access to rail a primary factor in site selection?*
    b. *How close do you consider a development to be walking distance to transit?*
    c. *Is rail access used in marketing?*
    d. *Do residential tenants mention access to public transport as important in their selection?*
3. *We developed a quantitative model that explores the relationship of station-area value with factors such as land use, race, and incomes. We noticed some stations have remarkably low real estate values very near to downtown. Can you provide more insight?*
    a. *Do you develop real estate near downtown?*
    b. *What are some of the barriers to developing near light rail stations such as Cedars (Red & Blue lines), MLK or Lawnview Stations (Green Line), and White Rock station (Blue Line North).*
    c. *We identified areas of high median incomes as also having among the highest property values near to transit.*

4. *We are concerned about new transit-oriented developments near light rail stations. Are you familiar with TOD?*
    i. *Transit-oriented developments are designed to maximize the number of available destinations near public transportation that encourage transit usage. They are characterized by high-density residential, commercial, and leisure spaces connected with walking paths or walkable streets, usually around a central transit stop, and typically feature much less than standard parking minimums.*
    b. *Are transit-oriented developments permitted near light rail stations (to your knowledge)*
    c. *Does the city reduce parking minimums or increase floor-area ratios (FAR) near light rail?*
    d. *Is land near stations zoned appropriately to support new TOD?*
    e. *Does your company or agency have to request variances to zoning codes or rules to construct new developments?*
    f. *What other barriers exist to transit-oriented development around DART light rail stations? (Financing, demand, construction costs, neighborhood activists or redevelopment /historic preservationists?)*
5. *What new policies might be adopted by DART or area cities to stimulate more development near rail stations – especially in low income or racially diverse areas?*

Questions for stakeholders:

1. *What is your role at your organization & how long have you served?*
2. *How does light rail impact your community?*
    a. *Which light rail stations serve your community?*
    b. *How do community members utilize the transportation service?*
    c. *Have property owners experienced disproportionate real estate increases since the construction of the rail line?*
    d. *Have property tax valuations increased / tax bills gone up since the opening of the light rail line?*
3. *How would you describe your community?*
    a. *What is the character of the neighborhood near the light rail station?*
    b. *How expensive is housing in your community.*
    c. *Do you feel that housing is affordable in your community?*
    d. *Do community members have access to transportation?*
4. *We are interested in transit-oriented development (TOD) near light rail stations.*
    i. *Transit-oriented developments are designed to maximize the number of available destinations near public transportation that encourage transit usage. They are characterized by high-density residential, commercial, and leisure spaces connected with walking paths or walkable streets, usually around a central transit stop, and typically feature much less than standard parking minimums.*
    b. *Are there TODs currently in your community?*

    c. *Do you support TOD expansion in Dallas?*
        i. *Would you support a TOD in your community?*
    d. *What are some of the barriers to new development in your community?*
    e. *Some transit agencies use HUD funding to construct low-income housing near light rail lines. Would your community support a DART development agency or a DART-backed housing project?*
5. *How could or should DART improve access to your community?*

Thank you again for taking the time to talk with me today. If you have any questions or thoughts about my research or would like to receive a final copy of the report please contact me, Brennan Walter, at 785-564-2882 or my email, brennanw@ksu.edu

IRB Approval Letter

KANSAS STATE UNIVERSITY | University Research Compliance Office

TO: Dr. Gregory Newmark
Landscape Architecture/Regional and Community Planning
1093 Seaton Hall

Proposal Number: 10081

FROM: Rick Scheidt, Chair
Committee on Research Involving Human Subjects

DATE: 02/25/2020

RE: Proposal Entitled, "Why Station Areas Succeed: A Station Area Analysis of the US' Largest Light Rail Network"

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written - and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §46.101, paragraph b, category: 2, subsection: ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.

203 Fairchild Hall, Lower Mezzanine, 1601 Vattier St., Manhattan, KS 66506-1103 785-532-3224 Fax 785-532-3278
comply@k-state.edu | k-state.edu/comply

Appendix B - SPTD Land Use Codes

The State of Texas uses a standard general set of land use codes. These use a mix of letters and numbers and generally refer to a long list of various land use types. However, each county assessor's district is permitted to establish their own guidelines and codes if they fit inside the same State framework. Both Collin & Dallas counties vary from the state's list. To provide analysis on both county's data, I had to combine and generalize their very long lists of land use codes. In the chart below, I provide how I grouped land use codes (known as STDP codes). The left-hand columns are how I chose to group land uses, and the right-hand columns are the various codes from each county's dataset.

The following two tables are the original land use tables that can be retrieved from each assessor's district website and shows the original coding and description for each code.

Combined / Generalized Land Use Code Table

Table B-5 - Combined Land Use Code Table – Collin County Codes in boldface

Description	Code	**CCAD**/DCAD STDP Codes												
Single-family residential	SFR	**A1**	**A2**	**A3**	**A4**	A11	A12	A13	A20	M31	M32			
Multi-family residential	MFR	**B1**	**B2**	**B3**	**B4**	B11	B12	**F4**						
Commercial	COM	L10	M10	M20	**F1**	**F2**	F10							
Industrial	IND	**F2**	L20	**C5**	**C6**	C13	F20	G10	G30					
Vacant land zoned residential	RVCT	**C1**	**C2**	C11	O10	O11	C14							
Vacant land zoned commercial	CVCT	**C4**	**C5**	**C6**	C12	**E4**								
Rural, ranchland, and agriculture	RNCH	**D1CL**	**D1CLW**	**D1IP**	**D1IPW**	**D1NP**	**D1NPW**	**E1**	**E2**	**E3**	C14	D10	D20	E11
Government, Parks, Education	GOV	CE	CH	CI	CO	FE	OE	RE	SC	ST	S10	M20		
Utilities and other	UTIL	**M4**	**J1**	**J2**	**J3**	**J4**	**J5**	**J6**	**J7**	S10	J10-	-J70		

Collin Central Appraisal District Land Use Code Table

Code	Name	Description
A1	Residential Single Family	
A2	Residential Mobile Home	
A3	Residential Condominium	
A4	Residential Townhomes	
B1	Residential Multi-Family	
B2	Residential Duplex	
B3	Residential Triplex	
B4	Residential Quadplex	
C1	Residential Single Family	
C2	Residential Single Family	
C3	Commercial	
C4	Commercial	
C5	Industrial	
C6	Industrial	
C9	Newsub	
D1CL	Cropland	Ag Land
D1CLW	Cropland Wildlife	Ag Land
D1IP	Improved Pasture	Ag Land
D1IPW	Improved Pasture Wildlife	Ag Land
D1NP	Native Pasture	Ag Land
D1NPW	Native Pasture Wildlife	Ag Land
D6	Restricted Use	
E1	Farm And Ranch Single Family	
E2	Farm And Ranch Mobile Homes	
E3	Farm And Ranch Other Improvements	
E4	Undeveloped	
F1	Commercial	
F2	Industrial	
F3	Office	
F4	Condominium	
J1	Utility/Water System	
J2	Gas Company	
J3	Electric Company	
J4	Telephone Company	
J5	Railroad	
J6	Pipeline	
J7	Railroad Corridor	
M4	Miscellaneous	

Table B-6 - Collin Central Appraisal District Land Use Code Table

Dallas Central Appraisal District (DCAD) Code Cross-Reference Table

Dallas Central Appraisal District
DCAD SPTD Code / PTAD Property Class Code
Cross-Reference List

DCAD SPTD Code	PTAD Property Class Code	Property Class
A11	A	SINGLE FAMILY RESIDENCES
A12	A	SFR - TOWNHOUSES
A13	A	SFR - CONDOMINIUMS
A20	A	MOBILE HOME ON OWNERS LAND
B11	B	MFR - APARTMENTS
B12	B	MFR - DUPLEXES
C11	C	SFR - VACANT LOTS/TRACTS
C12	C	COMMERCIAL - VACANT PLOTTED LOTS/TRACTS
C13	C	INDUSTRIAL - VACANT PLOTTED LOTS/TRACTS
C14	C	RURAL VACANT - LESS THAN 5 ACRES
D10	D1	QUALIFIED AGRICULTURAL LAND
D20	D2	NON-QUALIFIED LAND
E11	E	RANCH IMPROVEMENTS
E12	E	FARM IMPROVEMENTS
F10	F1	COMMERCIAL IMPROVEMENTS
F20	F2	INDUSTRIAL IMPROVEMENTS
G10	G1	OIL, GAS AND MINERAL RESERVES
G30	G3	MINERALS, NON-PRODUCING
J10	J	PRIVATE WATER SYSTEMS
J20	J	GAS COMPANIES
J30	J	ELECTRIC COMPANIES
J40	J	TELEPHONE COMPANIES
J51	J	RAILROAD CORRIDOR
J52	J	RAILROAD ROLLING STOCK
J60	J	PIPELINES
J70	J	CABLE COMPANIES
L10	L1	COMMERCIAL BPP
M10	L1	WATERCRAFT
M20	L1	AIRCRAFT
L20	L2	INDUSTRIAL BPP
M31	M1	MOBILE HOMES ON LEASED SPACES
M32	M1	MOBILE HOMES FOR SALE (ON LOTS)
N10	N	INTANGIBLES
O10	O	RESIDENTIAL - VACANT LOTS AS INVENTORY
O11	O	RESIDENTIAL - IMPROVEMENTS AS INVENTORY
S10	S	SPECIAL INVENTORY

As of July 25, 2011

Table B-7 - Dallas Central Appraisal District Land Use Code Table