Hedonic Value of Transit Accessibility: An Empirical Analysis in a Small Urban Area

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Disclaimer

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Abstract

Urban economic theory suggests that improved accessibility through transportation investments have the potential to drive up the bids for lands. A number of studies have investigated the impact of rail transit on home sales but produced mixed results. Further, few studies have explored how bus transit influences the lease rate of apartments. This question is more relevant than the relationship between rail transit and home prices because the scale of bus transit is regional as opposed to a narrow corridor of rail transit, and apartment dwellers are more likely to be influenced by transit accessibility than home owners. Using about 400 apartment dwellers in Fargo, this study developed a hedonic price model to determine implicit price of proximity to bus routes. The study found a negative impact of bus transit on apartment rent after controlling for other factors, however. We speculated that this negative relationship could represent spurious relationships from other causal factors as well as nuisance effects of bus transit itself.

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INTRODUCTION

Transportation systems provide travel options for people to move among spatially-segregated activities such as working, shopping, and entertainment. Therefore, transportation investments that ease movement from one location to another presumably have important impacts on the achievement of social objectives such as reducing congestion and improving the environment (Giuliano 2004; Wegener and Fürst 1999). How the enhanced accessibility affects land value is also important because transit investments are often justified by promoting economic development (e.g., Mackett and Edwards 1998).

The American Public Transportation Association states that "Across the country, dial-a-ride, bus, rail and commuter rail services are providing enhanced travel options and expanding access, often in dramatic ways. Better access means rising market value for adjacent properties and buildings" (APTA undated, p.2). According to urban economics, the relative increase in accessibility provided by transit facilities may increase property value because the larger demand for highly-accessible locations drives up the bid for lands in those locations (Mills and Hamilton, 1994). However, previous studies provide mixed results on how transit infrastructure influences property value. First, some studies found that proximity to rail transit has a positive impact on residential property value (Gatzlaff and Smith 1993; Haider and Miller 2000; Lewis-Workman and Brod 1997; Voith 1991). However, it is known the enhanced accessibility itself is not sufficient to stimulate urban development and increase property value; the positive impact of accessibility greatly depends on other factors such as economic situations, land use policies, and development subsidies (Cervero 1996; Gatzlaff and Smith 1993; Giuliano 2004). On the other hand, transit infrastructure may bring about nuisance effects due to noise and crime. For example, Nelson (1992) found that proximity to transit stations is positively associated with property value in lower-income neighborhoods but has a negative influence on property value in higher-income neighborhoods, although both neighborhoods are served by the same rail transit. This suggests that nuisance effects of the rail transit exceed accessibility effects in higher-income neighborhoods. Chen et al. (1998) found that property values decrease and then increase as the distance to transit stations increases, an interaction of a positive accessibility effect and a negative nuisance effect.

These studies intensively focused on the impact of rail transit (including heavy rail, light rail, and commuter rail) on home sales. We should also pay attention to the relationship between bus transit and values of rental properties. Although a single rail transit represents a huge amount of investment, bus transit has a much larger network in the region and carries the majority of transit passengers (Pucher 2004). In other words, the impact of rail transit on property value tends to be limited to the local corridor, while the influence of bus transit is likely to be regional due to its extensive network. Therefore, bus transit's influence on property value merits investigation. Generally, transit attracts patrons from people living in the urban core, transit-captives, and some choice users. Therefore, transit investments tend to have a limited impact on individuals' accessibility compared to highway investments. Given that many apartment dwellers are transportation-disadvantaged people, transit access and the level of service may have a larger impact on apartment dwellers than home owners. Further, apartment dwellers tend to value the importance of transportation factors in their residential choices, compared to home owners (Bina et al. 2006a, 2006b; Cao 2007). Therefore, transit infrastructure is more likely to affect lease rates than home prices.

Several studies have pointed to bus transit and/or rent value. Using real estate sales data collected a few years before and after introducing a new bus system in Denver in 1971, Koutsopoulos (1977) found that single-family houses close to bus routes tend to have higher values than those away from the bus system. Bina et al. (2006b) also found the number of bus stops per square mile is positively associated with home prices. Further, Benjamin and Sirmans (1996) showed that proximity to rail stations positively affects the lease rate of apartments in Washington, DC. Cervero (1996) revealed that the distance to BART stations has a negative impact on apartment rent in some neighborhoods but has no influence in other examined neighborhoods in the San Francisco Bay area. Bina et al. (2006a) is one of few studies investigating the influence of bus transit on lease rates. The study found the density of bus stops is negatively associated with apartment rents in Austin, TX. The researchers speculated that the noise of buses and the spread of bus services in lower-income neighborhoods might contribute to this negative association. The opposite impacts of the bus system on sale prices and lease rates may also arise from different sampling methods used in these two studies (Bina et al., 2006a; 2006b): choice-based sample vs. random sample. Bina et al. (2006a) pointed out the drawback of a choice-based sampling method and highly recommended a random sampling approach.

The purpose of this study is to explore the influence of transit facilities on the lease rate of apartments using the data randomly collected from apartment dwellers in Fargo, North Dakota. It aims to answer the following question: do transit services add value to adjacent apartments? The next section briefly reviews the hedonic price model. Section 3 describes the data and variables. Section 4 presents the results of correlation analysis and the hedonic model. The final section discusses the underlying reasons for the model results.

HEDONIC PRICE MODEL

The hedonic price model is commonly used to determine the impact of transportation investments on property value. The model assumes that goods are characterized as a package of inherent attributes, and the observed prices of goods reflect the utility (or implicit prices) of these attributes (Rosen 1974). Therefore, the value of a residence is the summation of implicit prices for the characteristics associated with the residence. What constitutes the characteristics of a residential property? Previous research points to location, structure, and neighborhood attributes (e.g., Chin and Chau 2003; Lewis-Workman and Brod 1997). Some of these attributes are summarized in Table 1.

Table 1 Influential Attributes of Property Value

Category	**Attributes**
Location	Distance to the central business district
	Distance to the nearest station of transit
	Level of services of transportation
	Aesthetic or obstructed view
	Geomancy
	…
Structure	The number of rooms including bedroom and bathroom
	Floor area
	Age of the building
	Quality of the building
	The existence of a basement, garage, patio, etc.
	Appliances (e.g., kitchen equipment) and amenities (e.g., swimming pool)
	…
Neighborhood	Social class of neighborhood
	Schools, hospitals, and places of worship
	Crime rate
	Noise
	Proximity to commercial districts
	…

Source: Chin and Chau (2003)

In mathematical form, the hedonic function of an apartment can be expressed as:

$$Y = f(L, S, N),$$

where Y stands for the dependent variable: rent of an apartment; L, S, and N denote location, structural, and neighborhood characteristics of the apartment, respectively. The partial derivative of the function with respect to an attribute represents the marginal implicit price (shadow price) of that attribute. For a linear regression model, the coefficient of an attribute is the shadow price of that attribute.

DATA AND VARIABLES

The data used in this study comes from a self-administered telephone survey conducted in Fargo, North Dakota. Fargo, located in the Red River Valley region, is a typical small city in the Midwest (Figure 1). The city's land area is about 30 square miles, and the population was 90,599 in the 2000 census. Fargo is a major transportation hub for the surrounding regions: two interstate highways (I29 and I94) run across the city (Figure 2). Inside the metropolitan area, Metro Area Transit (MAT, http://www.matbus.com) operates 18 routes to provide transit services for three adjacent cities: Fargo, West Fargo, and Moorhead. In 2006, Fargo MAT provided about 900,000 one-way passenger trips.

Figure 1 Geography of Fargo in the Region.

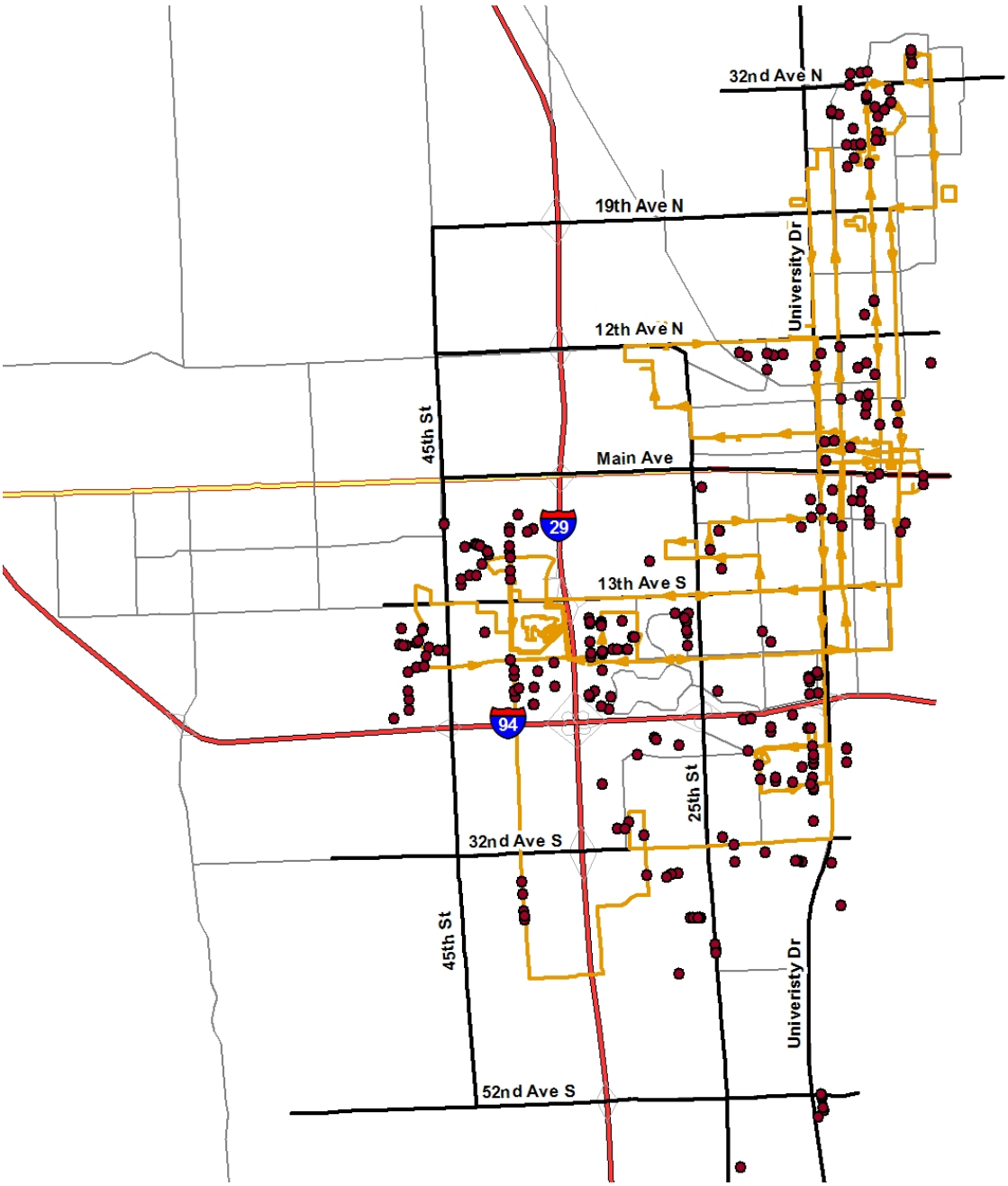

Figure 2 Residential Locations of Respondents and Transit Routes.
Note: The dots are observations and the lines with arrows are bus routes.
A detailed route map is available at http://www.matbus.com/Documents/FargoBusRoutes.pdf.

Survey questions were developed from questionnaires used in previous research projects by the first author and Dr. Kara Kockelman. The survey was pre-tested on students and staff of North Dakota State University. Participants were asked first to complete the survey, then to discuss the survey questions with the researchers in one-on-one interviews. Based on these pretests, survey questions were modified and refined.

A database of apartment dwellers was purchased from AccuData America (http://www.accudata.com/). In May and June 2007, a contract interviewer from the National Agriculture Statistics Service phoned respondents randomly selected from the database. Since those who do not answer the phone may substantially differ from those answering the phone, a callback procedure was adopted. As an incentive to complete the survey, respondents were told they would be entered into a drawing to receive one of five $50 cash prizes. Ultimately, among 1,395 individuals who answered the phone, 415 no longer lived in apartments. The number of responses totaled 424, equivalent to a 43.2% response rate based on the valid respondents only. As shown by the dots in Figure 2, most of the respondents were gathered in several locations, which reflects the cluster of apartment buildings. Note that 26 respondents were removed from the analysis because they either lived in senior centers or subsidized apartments, and the nominal rent they reported does not reflect the true value of properties.

In the survey, respondents were asked to report their monthly rent (the total rent if they shared an apartment). Moreover, a series of questions asked attributes of the apartment (e.g., number of bedrooms and bathrooms as listed in Table 2). These attributes serve as control variables. As shown later in Table 3, respondents were also asked to indicate how true 20 attributes were for their current apartments and neighborhoods, on a four-point ordinal scale from “Not at all true” (1) to “Entirely true” (4). The characteristics as perceived by respondents reflect fundamental differences in attributes of residential environments.

Table 2 Sample Characteristics

	N	Minimum	Maximum	Mean	Std. Deviation
Apartment attributes					
Monthly rent	379	265	1140	604.26	174.04
# bedrooms	398	1	3	1.96	0.58
# bathrooms	398	1	2.5	1.17	0.26
With a patio, balcony, deck or porch	398	0	1	0.73	0.44
Living in the garden level	397	0	1	0.21	0.41
Controlled access	397	0	1	0.82	0.39
Furnished apartment	398	0	1	0.01	0.10
Garage cost included in the rent	398	0	1	0.74	0.44
Apartment size	207	250	2000	986.76	249.93
Appliances provided in the apartment					
Refrigerator	398	0	1	1.00	0.05
Stove	398	0	1	0.99	0.10
Microwave	398	0	1	0.29	0.45
Dishwasher	398	0	1	0.82	0.38
Washer/dryer	398	0	1	0.20	0.40
Utilities paid by dwellers					
Electricity	398	0	1	0.86	0.35
Snow removal	398	0	1	0.01	0.09
Heat	398	0	1	0.20	0.40
Water	398	0	1	0.04	0.20
Sewer/garbage	398	0	1	0.04	0.20
Amenities offered by apartment complex					
Clubhouse/community room	398	0	1	0.24	0.43
Swimming pool	398	0	1	0.14	0.35
Landscaped garden	398	0	1	0.09	0.29
Fitness or sport facilities	398	0	1	0.24	0.43
Playground	398	0	1	0.09	0.29
Free cable TV/internet	398	0	1	0.07	0.25
Land use characteristics					
Accessibility	395	545.54	1209.78	957.28	172.00
Population density	395	0	21929.67	6117.33	4319.66
Employment density	395	0	24768	3061.07	4769.24
Retail employment density	395	0	5513.70	722.90	1226.03
Service employment density	395	0	19139.92	1787.76	3409.39
Travel time to the CBD	395	1.69	16.98	9.35	3.27
Living w/in 1/8 mile of transit routes	395	0	1	0.56	0.50
Living w/in 1/4 mile of transit routes	395	0	1	0.80	0.40
Living w/in 1/2 mile of transit routes	395	0	1	0.92	0.27

Note: if a variable ranges from 0 to 1, it is a dummy variable.

Following the survey, several land use characteristics were calculated at the traffic analysis zone (TAZ) level. Using the data from regional travel demand forecasting model, the study first computed a few density measurements and vehicular travel time to the central business district (CBD) as shown in Table 2. Further, regional accessibility was computed using the following gravity-based measure:

$$A_i = \sum_j O_j f(t_{ij}) = \sum_j O_j (a \times t_{ij}^{\ b} \times e^{c \times t_{ij}}),$$

where A_i is the accessibility of TAZ(i); O_j is the number of jobs in TAZ(j); $f(t_{ij})$ is the friction function to travel between TAZ(i) and TAZ(j). Here, calculations adopted the HBW (home-based work) Gamma function coefficients for friction factors where a = 28507, b = -0.020, and c = -0.123. Using GIS, three dummy variables were created to indicate whether a respondent lived within 1/8, 1/4, or 1/2 mile (network distance) of transit routes, respectively. In Fargo, although there are designated bus stops, the MAT bus stops at a shelter location or any corner as long as it is safe traffic-wise. Therefore, the distance to the transit route is actually the network distance to the bus stop.

RESULTS

The correlations of the monthly rent with objective land use characteristics at the TAZ level were examined. As shown in Table 3, most of these characteristics are significantly associated with the rent, except the three measurements of employment density. These associations reveal that apartments located in highly-accessible, dense areas tend to have lower rents than those in the areas with a low level of accessibility and density; the rent of apartments tends to increase as vehicular travel time to CBD increases. Generally, these associations seem to be counterintuitive due to the commonly-believed premium for high accessibility. On the other hand, these associations may represent spurious relationships. For example, accessibility may act as a proxy for such attributes as space: the farther an apartment is from the CBD, the more spacious it is, and the more expensive. Apartments within specific distances (1/8, 1/4, 1/2 mile, respectively) of bus routes tend to have lower rents than those away from transit facilities; and the closer apartments are to bus routes, the stronger the association is. Therefore, it seems that proximity to bus routes has a negative impact on apartment rent.

Table 3 Corrections of Rent with Attributes of the Apartment and Neighborhood

	Correlation	**P-value**
Objective measures		
Accessibility	-0.199**	0.000
Population density	-0.176**	0.001
Employment density	0.031	0.545
Retail employment density	-0.027	0.601
Service employment density	0.053	0.309
Travel time to the CBD	0.277**	0.000
Living w/in 1/8 mile of bus routes	-0.249**	0.000
Living w/in 1/4 mile of bus routes	-0.220**	0.000
Living w/in 1/2 mile of bus routes	-0.184**	0.000
Perceived measures		
Affordable living unit	-0.219**	0.000
Relatively new living unit	0.410**	0.000
High quality K-12 schools	0.090*	0.097
Living on cul-de-sacs	-0.025	0.636
Attractive appearance of neighborhood	0.093*	0.071
High level of upkeep in neighborhood	0.135**	0.009
Sidewalks throughout the neighborhood	-0.046	0.371
Safe neighborhood for kids to play outdoors	0.071	0.177
Easy access to the interstate highway	0.088*	0.091
Easy access to public transit	-0.101*	0.055
Parks and open spaces nearby	0.028	0.589
Local shopping areas within walking distance	-0.021	0.679
Easy access to a regional shopping area	0.071	0.168
Close to workplace	-0.134**	0.011
Close to friends or family	0.112**	0.030
Quiet neighborhood	0.079	0.126
Low crime rate within neighborhood	0.158**	0.002
Low level of car traffic on neighborhood streets	0.050	0.335
Economic level of neighbors similar to yours	0.112**	0.033
Ethnicity and race of neighbors similar to yours	0.020	0.702

* significant at the 0.1 level; ** significant at the 0.05 level.

In addition, the lease rate is significantly correlated with various perceived measures of the apartment and neighborhood (Table 3). In general, the findings are consistent with the research expectations. Note the age of the apartment (relatively new living unit) has the largest correlation with the rent. Easy access to an interstate highway has a positive association with the rent, but easy access to public transit is negatively associated with the rent. Thus, the influence of both objective and perceived measures of public transit point to a negative impact of bus transit on the lease rate of apartments.

The ordinary least squares (OLS) technique was used to determine hedonic value of transit accessibility, controlling for other factors. Potential explanatory variables were entered into the model in groups, starting with apartment attributes reported by respondents, followed by objective land use characteristics measured at the TAZ level, then characteristics of the current apartment and neighborhood perceived by respondents. At each step, insignificant variables were dropped, and the model was re-estimated before the next set of variables was entered. Variation inflation factor was used to test multicollinearity among explanatory variables. This statistic is smaller than 2 for all variables significant in the final model. Therefore, the multicollinearity is not a concern.

Table 4 presents the hedonic price model for the apartment. The adjusted R-square for the model is 0.740, indicating a reasonable goodness-of-fit compared to other hedonic models. A comparison of standardized coefficients shows that location and neighborhood attributes of an apartment tend to have a smaller impact on apartment rent than does its structure attributes.

Table 4 Hedonic Price Model: Linear regression

	Coeff.	**Std. Coeff.**	**P-value**
Constant	268.480		0.000
# bedrooms	92.039	0.300	0.000
# bathrooms	67.881	0.170	0.000
With a patio, balcony, deck or porch	44.851	0.113	0.000
Appliances provided in the apartment			
Microwave	35.335	0.091	0.003
Dishwasher	52.842	0.117	0.000
Washer/dryer	78.152	0.177	0.000
Amenities			
Clubhouse/community room	148.095	0.362	0.000
Swimming pool	30.006	0.058	0.053
Landscaped garden	37.789	0.061	0.029
Free cable TV/Internet	57.800	0.075	0.008
Utilities paid by dwellers			
Heat	-64.653	-0.149	0.000
Objective measures			
Living w/in 1/8 mile of bus routes	-23.461	-0.067	0.022
Travel time to the CBD (min.)	-4.906	-0.092	0.004
Retail density	-0.010	-0.072	0.015
Perceived measures			
Relatively new living unit	8.997	0.056	0.078
Living on cul-de-sacs	-19.682	-0.062	0.023
N	369		
R-square	0.751		
Adj. R-square	0.740		

Not surprisingly, the numbers of bedrooms and bathrooms are positively associated with the lease rate, with bedrooms having a larger impact. A patio, balcony, deck, or porch adds about $46 to apartment rent, all else equal. Additional appliances provided in an apartment tend to increase the value of the apartment. These appliances not only have the value themselves, but also indicate the luxury nature of the apartment. Amenities offered by the apartment complex also have positive impacts on the lease rate. If the dwellers are responsible for heat (heat is expensive in the winter), the rent is reduced by $63 on average. A newer apartment also tends to have a higher lease rate.

After controlling for these factors, the study finds that some measures of accessibility are associated with apartment rent. Interestingly, the model shows that vehicular travel time to CBD has a negative association with the rent. That is, the rent tends to be higher in areas with higher auto accessibility, all else equal. This result is different from their positive association observed in the correlation analysis, and confirms speculation that auto accessibility may act as a surrogate for other factors. Living on cul-de-sacs has a negative impact on apartment rent. This relationship is reasonable due to the lower accessibility of dead-end streets. It is worth noting that easy access to interstate highways is insignificant in the model, suggesting little location advantage of highway coverage in a small urban area. Apartments located in a TAZ with a higher retail employment density tend to have a lower value than other apartments. This association may result from the noise, traffic, and parking associated with retail businesses. Therefore, although mixed-use neighborhoods can improve the accessibility of residents, an excessive mix may have a negative impact on residential properties.

The model also shows that, on average, apartments located within 1/8 mile of bus routes are $18.41 less expensive than other apartments. This suggests that access to bus transit does not increase the value of apartments adjacent to bus routes. Note that if living within 1/8 mile of bus routes is manually removed from the model, neither living within 1/4 mile of bus routes nor living within 1/2 mile of bus routes is significant in the model. This finding suggests that after controlling for other factors, only properties very close to bus routes tend to have low rents.

DISCUSSION

Does better access resulting from transit infrastructure increase the value of adjacent properties and buildings? This study explores the impact of bus transit on the lease rate of residential properties in a small urban area. The results show that vehicular accessibility increases the rent of apartments. In particular, all else equal, vehicular travel time to the CBD (the longer the time, the lower the accessibility) is negatively associated with the rent; apartments on cul-de-sacs (less accessible) tend to have a lower rate than other apartments. However, transit accessibility appears to have a negative impact on the value of apartments. Specifically, after controlling for other factors, apartments located within 1/8 mile of bus routes tend to have lower lease rates than other apartments.

"Better access means rising market value for adjacent properties and buildings" (APTA undated, p.2). Why does providing bus transit seem to lower property value in general (e.g., Bina et al. 2006a), and in Fargo in particular? This study speculates that this observed relationship can be attributed to the twofold. First, the negative impact of transit infrastructure on apartment rent is the net effect of a weak positive accessibility effect and a negative nuisance effect. The population affected by the transit accessibility is so narrow (mainly transit dependents) that improved accessibility cannot trigger any substantial impacts on residential properties. Although bus transit provides an additional travel option for people in a region, it has a limited ability to improve *accessibility of people* because Americans overwhelmingly rely on private vehicles for their daily activities. This also holds true for apartment dwellers. In small urban areas, auto dependence is even more prevalent since, historically, people in these areas tend to be independent and have little knowledge/experience about public transit.

Transit itself may have nuisance effects such as noise, crime, and negative image. The noise from rail transits can be a problem (e.g., Chen et al. 1998). However, a bus is not likely to be a major source of noise; at most it is a large vehicle. Transit may also carry negative public perceptions and hence decrease the value of adjacent properties. Transit-related crime is a well-known phenomenon in large metropolitan areas in the United States (Loukaitou-Saderis et al. 2002). Public concern over safety and security is one of the major reasons that some people live away from transit stations and do not use them (Ingalls et al. 1993). However, safety is not a major concern in Fargo. Compared to the national average, Fargo has a much lower crime index. And according to the MAT, there is no pattern of transit-related crimes in Fargo although the neighborhood around the Ground Transportation Center (a transfer location), actually downtown Fargo, has a relatively high rate of crime. Negative images of public transportation may matter. There are many web-based debates that transit riders are treated as second-class citizens by other people and even the federal government. These negative images may deter some renters from living close to bus routes and hence decrease the values of adjacent apartments.

Second, proximity to bus routes may act as a proxy for other factors. One of the fundamental functions of public transit is to provide travel alternatives for transit dependents, and ridership is the centerpiece for initial route design and any further extension of the transit network given budget constraints. Transit agencies tend to prioritize services for neighborhoods accommodating many transit captives who are low-income, disabled, elderly, and/or have no personal vehicles. The availability of transit services may also attract transit captives into such neighborhoods. In Fargo, most bus routes were intentionally designed to connect low-income neighborhoods with workplaces and services. For example, many low-income people live in the southwestern corner of I94 and University Drive where a Kmart is located; many elderly people live in the neighborhood around 32nd Avenue North where services are relatively abundant; the bus route along 32nd Avenue South was designed to connect public housing (Figure 2). Therefore, it may be these neighborhoods, rather than the transit system, that cause the low lease rate of apartments close to bus routes.

The CBD tends to have a dense transit network. In Fargo, the neighborhood around the east end of Main Avenue is the traditional center (Figure 2), which was built in the late nineteenth century. Compared to the apartments in outer suburbs, apartments in the CBD tend to have a lower lease rate due to the appearance and functionality of older apartments. Therefore, the impact of bus transit can be a surrogate for the age of apartments. This study found that older apartments tend to have a lower lease rate. In addition, decentralization can reduce the advantages of a central location and, hence, lower the value of apartments in the CBD (Giuliano, 2004). Because many businesses and services have moved to the regional shopping center around 13th Avenue South mentioned later, downtown Fargo has been losing its attractiveness as a center, and its surrounding areas have gradually become low-income neighborhoods.

The agglomeration of businesses has the potential to attract more consumers than a single business. For the convenience of both consumers and employees, transit agencies tend to establish extensive routes in commercial districts. Commercial districts may have nuisance effects such as noise, traffic congestion, and shortage of on-street parking. In Fargo, the northwestern corner of the intersection of I29 and I94 is the regional shopping center where many strip malls and small businesses are clustered. The streets in this area are the busiest, especially during the weekend. Therefore, the low rent of apartments close to bus routes may result from their proximity to commercial districts and busy streets.

Overall, bus transit seems to have little impact on improving accessibility and increasing property value. Based on previous research and the information from local authorities, the negative association between transit accessibility and apartment rent is more likely to be a result of spurious relationships: proximity to bus routes is a surrogate for other factors. Although this study finds that bus transit lacks the potential to increase the value of apartments, this result does not intend to discourage the continuing investments of transit infrastructure. In the data, 7.5% of apartment dwellers took a bus to grocery stores or shopping malls at least once per month, and 13% have taken a bus to go shopping. Therefore, transit services play a crucial role in improving the mobility and, hence, quality of life of a niche market.

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