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Crush Capacity or Nearly Empty: Demographics and MetroBus Utilization

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Preamble

From 2008 to 2009, Metro, the Saint Louis public transportation agency, began making service cuts to its bus system (MetroBus), mostly in Saint Louis County. The cuts were deemed necessary because declining income from county taxpayers and rising operations costs had created a multimillion-dollar budget shortfall. Metro planned to reduce MetroBus service by 43 percent, MetroLink service by 32 percent, and paratransit (Call-A-Ride) service by 15 percent. Metro proposed a half-cent sales tax increase in Saint Louis County to revive this lost service.[1]

To garner support for that tax increase, supporters told the stories of those who relied on endangered bus service. These stories concerned those who needed bus service to get to work, like Eddie Caumiant of Service Employees International Union Local 1. He told reporters that

> We use Metro because we can't get to those jobs that are in the county any other way than by using Metro. So it is near and dear to our heart because it is our life's blood.[2]

Despite the service restoration and more spending than ever, MetroBus ridership is still lower than it was in 2009, the year significant cuts to MetroBus took place.

Jobs were only part of the equation. Proponents of the tax increase pointed out that public transportation was a clear need for those who were disabled elderly. As one supporter put it:

> There is a large number of disabled and elderly people who depend on Metro to get to the doctor, to their jobs and to do the basic functions of life and continue to live independent lives. . . . If county voters pass it, then it will save those services.[3]

Metro also promised improved service from a tax increase, including newer buses, Bus Rapid Transit, and possible MetroLink extensions. Ultimately, in April 2010, Saint Louis County voters approved the half-cent tax increase. Metro's leadership hailed the result as the dawn of a new day for Saint Louis transit, and that "the victory belongs to all of St. Louis."[4]

While the victory for those residents who saw their bus routes saved is not in question, the victory for MetroBus and the Saint Louis region as a whole is far from clear. Despite the service restoration and more spending than ever, MetroBus ridership is still lower than it was in 2009, the year significant cuts to MetroBus took place. In fact, while inflation-adjusted spending on the Saint Louis bus system has increased by almost 30 percent since 1991, ridership has fallen from 46 million rides a year to less than 30 million.[5]

While more and more is spent carrying fewer passengers, some parts of the MetroBus system have significant crowding, especially the busiest route in the city, 70 Grand. More than three years after the taxes increased to improve bus service, one rider called the crowding on the bus a "nightmare,"[6] and the need to wait for infrequent service has meant that, as one rider put it,

> You can't plan when you are going to be someplace. . . . My office is flexible. If I arrive a little later, I can stay a little later. If I had something that was more time-dependent, I would have to swear off the bus.[7]

While Metro is currently putting in larger buses on the 70 Grand line, there are other busy bus routes in the city that come infrequently, even during rush hour.

Furthermore, the bright future of Saint Louis transit remains over the horizon. Bus Rapid Transit lines do not yet exist in Saint Louis, although they are in the planning phase. Even further off is the promise of a MetroLink expansion, which could easily cost more than a billion dollars.[8]

Three years after the Saint Louis County Metro tax increase, it is clear that the system is roughly similar in terms of level of service as it was before the tax increase, although ridership has yet to recover. And while some bus service was undoubtedly saved, persistent shortcomings continue to hobble the use and perception of Metro where the system could carry more riders. The quick reaction to these observations may be to criticize Metro for failing to deliver and wasting money, but perhaps it is more useful to ask why Metro provides the type of service it does and what makes it so dependent on taxpayer subsidies. The following essay explores both this question and what kind of public transportation system can serve the needs of Saint Louisans who depend on the bus, and how the system can rely less on whims of general taxpayers.

Introduction

The Bi-State Development Agency's MetroBus system is a critical component of the Saint Louis metropolitan area's transportation system. It accounts for close to 30 million passenger trips a year.[9] Thousands of residents use buses to commute to work and other destinations.[10] Many of the bus riders have low incomes and often do not have access to personal vehicles, which makes them dependent on a well-functioning bus system. The Bi-State Development Agency, through Metro, has multiple goals for its bus system, including increasing ridership, maintaining area coverage, and enhancing revenue.[11] Despite these goals, MetroBus ridership has fallen in the last decade, as has the percentage of Saint Louisans using the bus to commute to work.[12] At the same time, the costs of maintaining and operating the bus system continue to rise.[13] Achieving the goals of cost-effectiveness and greater ridership may require a change in bus route priorities. This essay attempts to 1) describe the current pattern of MetroBus service provision and 2) describe what factors predict for bus routes that have high financial performance.

An analysis of the current MetroBus network suggests that Metro might be able to better optimize financial return on its bus routes by shifting resources to high population density areas in Saint Louis City with low car ownership. Routes traveling to higher car ownership in Saint Louis and Saint Clair counties may be less optimal and might be tranformed into more efficient van-share systems or privatized.

This paper is divided into three parts. The first is a literature review and description of the relevant data. The second is an in-depth look at how the Bi-State Development Agency's MetroBus system currently operates, and what demographic factors predict for MetroBus's current levels of service provision. The third part of this essay describes the geographic distribution of high and low financially performing bus routes with statistical models that indicate which demographic factors predict for more efficient bus routes at the census tract level.[14]

Part I

Literature Review

This study will, in part, analyze the financial efficiency of MetroBus routes. Previous studies have approached bus operation efficiency from both a financial and operational perspective. Some used case studies to evaluate bus efficiency in terms of variation in running times (Strathman, Kimpel, Dueker, Gerhart, and Callas, 2001).[15] Moore conceptualized rider efficiency on bus routes as ridership multiplied by median income, and he found little

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Demographic factors that lead to higher bus utilization are incomes 20 to 40 percent below the city's median, transit dependency, connection to the central business district or other employment clusters, and short trip lengths.

relationship between fares and this measure of efficiency (Moore, 1994).[16] Others, like Nakanishi, attempted to evaluate the performance of bus systems (or bus routes) using data envelopment analysis,[17] generally with the emphasis on the productivity of local bus services (Nakanishi, 2000).[18] This type of analysis compares bus systems based on how they deploy their finite resources. Comparatively few studies look at the demographic factors that contribute to the financial performance of individual bus routes. Those that do find that higher bus utilization leads to more ridership and, in turn, higher farebox recovery (Cervero, 1992).[19] Demographic factors that lead to higher bus utilization are incomes 20 to 40 percent below the city's median, transit dependency,[20] connection to the central business district or other employment clusters, and short trip lengths. This paper will look at whether Cervero's findings on income, workplace connections, and transit dependency are replicable in the Saint Louis area. Since many studies (Frank and Pivo, 1995)[21] (Metrans Project, 2005)[22] have found that population density increases transit utilization, that factor will be looked at as well.

Another aspect of bus efficiency that this paper will address is that of intermodal transit hubs. Transit hubs often use rapid transit stations as hubs, while slower local buses act as the spokes, bringing riders to final destinations. Specifically, Saint Louis' bus system is partially designed around the MetroLink, a light rail line running through the center of Saint Louis City, Saint Louis County, and Saint Clair County.[23] While this paper mainly focuses on this factor as a control variable to isolate other demographic effects, an understanding of the empirical basis for intermodal hubbing is important for proposing proper control variables if hubs impact route efficiency. The literature on intermodal hub efficiency often focuses on how feeder bus routes improve fixed transportation lines (Jiang Binglei, 1998; Zhang Haiye, 2010).[24] Wang and Po looked at government policies and regulations in designing bus routes in Hong Kong and suggested robust multimodal transit hubs would increase Hong Kong's transit efficiency (Wang and Po, 2010).[25]

Data Description

The data used in this essay comes from three principle sources: Metro Saint Louis' route level data, Metro's October route level financial performance, and demographic information from the Census Bureau. For simplicity, this essay only analyzes the performance of weekday bus routes, which generally have higher passenger ridership and better financial performance compared to weekend routes. Metro Saint Louis' route level data provides daily stop information for all trips on all Metro routes.[26] Every daily stop on every bus trip on every bus route is coded as an individual data point; there are 270,813 individual stops all together.[27] The financial performance of the MetroBus routes was provided by the Metro Agency, which consisted of October data on the performance of each bus route. Metro usually reports its highest ridership figures in October, and hence figures are skewed in favor of good financial performance for all bus routes.[28] The third source of data is demographic information on individual census tracts in Saint Louis City, Saint Louis County, and Saint Clair County, of which there are 365 areas in total. Demographic variables include population density from 2010[29] and worker population,[30] vehicle ownership,[31] and median income from 2012.[32]

Bus stop, route financial performance, and census demographic data were combined to create maps detailing the distribution of routes and underlying factors that previous literature have shown to affect route performance. For regressions, the unit of analysis is the census tract, not the bus route. The total stops per census tract, once corrected for census tract area, act as the dependent variable. To prevent stops that were effectively on the border of two census tracts from altering the results, another dependent variable, which included all route stops inside of or within 200 meters of census tract, was created. The independent variables are population density, workplace population density, vehicular availability, median income, dummies for MetroLink stations (the area's light rail system), and a Saint Louis City dummy variable.

Part II: Where MetroBuses Run: Visual and Statistical Evidence

The MetroBus system is extensive, with 74 routes and more than 100,000 weekday passengers during its busiest months. In 2013, Metro had 382 buses with seating capacities varying from 29 to 43 passengers per bus.[33] Table 1 describes general operations and the financial performance of the system.

One element of Table 1 that may be suprising is that even during weekdays in peak months the bus system loses almost two dollars for each passenger boarding. The amount that a bus loses per passenger is directly tied to the farebox recovery ratio (FBR). The farebox recovery ratio is defined as the total revenue from a bus route divided by the operating costs of that bus route. An FBR of 100 percent would mean that a bus breaks even (in terms of operating expenses) for each passenger. Lower than 100 percent means the route loses money per passenger, and higher than 100 percent means the route gains money per passenger.

Table 1

MetroBus by the Numbers (October Weekdays)

Total Bus Routes	74
Revenue Vehicle Trips Per Day	4,262[1]
Total (Miles) Per Day	63,946
Average Passenger Per Day	100,032
Total Operating Cost Per Day	$304,067.83
Total Revenue Per Day	$106,694.21
Farebox Recovery Ratio	35.09%

The MetroBus system primarily serves Saint Louis City, Saint Louis County, and Saint Clair County. Metro has a broad taxing district and has an obligation to provide transit service to most areas in these three counties.[34][35] For an area that is not served by bus or rail, Metro often provides expensive demand response service.[36] Demand response service is small bus door-to-door service at a heavily subsidized fee. Metro therefore has a strong incentive

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The distribution of weekday bus stops by census tract shows that most MetroBus service occurs in Saint Louis City, the northeast part of Saint Louis County, and the central corridor in Saint Clair County.

to provide wide bus coverage; on this measure at least it has some success. Figure 1 shows the area within 400 meters and 1,200 meters surrounding all MetroBus stops.

As Figure 1 demonstrates, much of the city—and a good portion of Saint Louis County—are within 400 meters of a bus stop. Virtually the entire city (96 percent) is within 1,200 meters of a bus stop, as is most of Saint Louis County. Saint Clair County has the lowest area coverage, with only 28.45 percent of the county within a mile of a bus stop. Overall, 32.46 percent of the three-county Metro service area is within a mile of a bus stop. Table 2 shows the exact area coverage by geographical unit in greater detail.

The distribution of weekday bus stops by census tract (see Figure 2) shows that most MetroBus service occurs in Saint Louis City, the northeast part of Saint Louis County, and the central corridor in Saint Clair County. In addition, the central section of Saint Louis City—from downtown to Clayton—has particularly pronounced bus service.

To see what census tract demographic factor predicts for more bus stops within that tract, I employed an OLS regression model. The dependent variable was the stops-per-census tract, found by spatially joining the geographic data for bus stops onto a layer of census tracts. The mean number of stops per census tract (of within 200 meters of that tract) was 1,775.7 per square mile, or 2.77 per acre. The model—where population density refers to population per square mile, worker density refers to daily workers per square mile, median income refers to median household income, and percent of population with no vehicles available refers to the total percentage of households with no access to a personal vehicle—is as follows:

Stops per census tract = β_1 *population density* + β_2 *worker density* + β_3 *median income* + β_4 *percent of population with no available vehicle* + *e*

A regression of these factors on weekday bus stops per census tract per square mile (see Table 3, page 8) shows that as population density, workplace density, and percentage of population without cars increases, so does the forecast of weekday bus stops. A higher median income predicts for fewer bus stops in the area.

However, there are other factors that predict where Metro provides bus service, the most prominent being

Figure 1

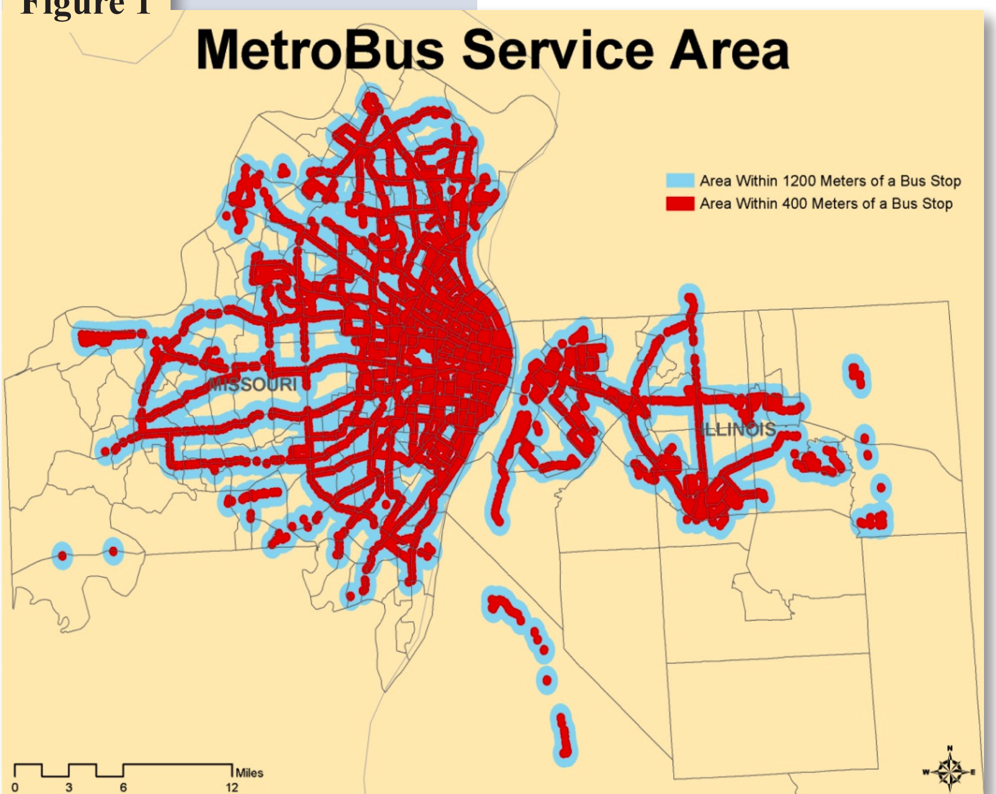

Figure 2

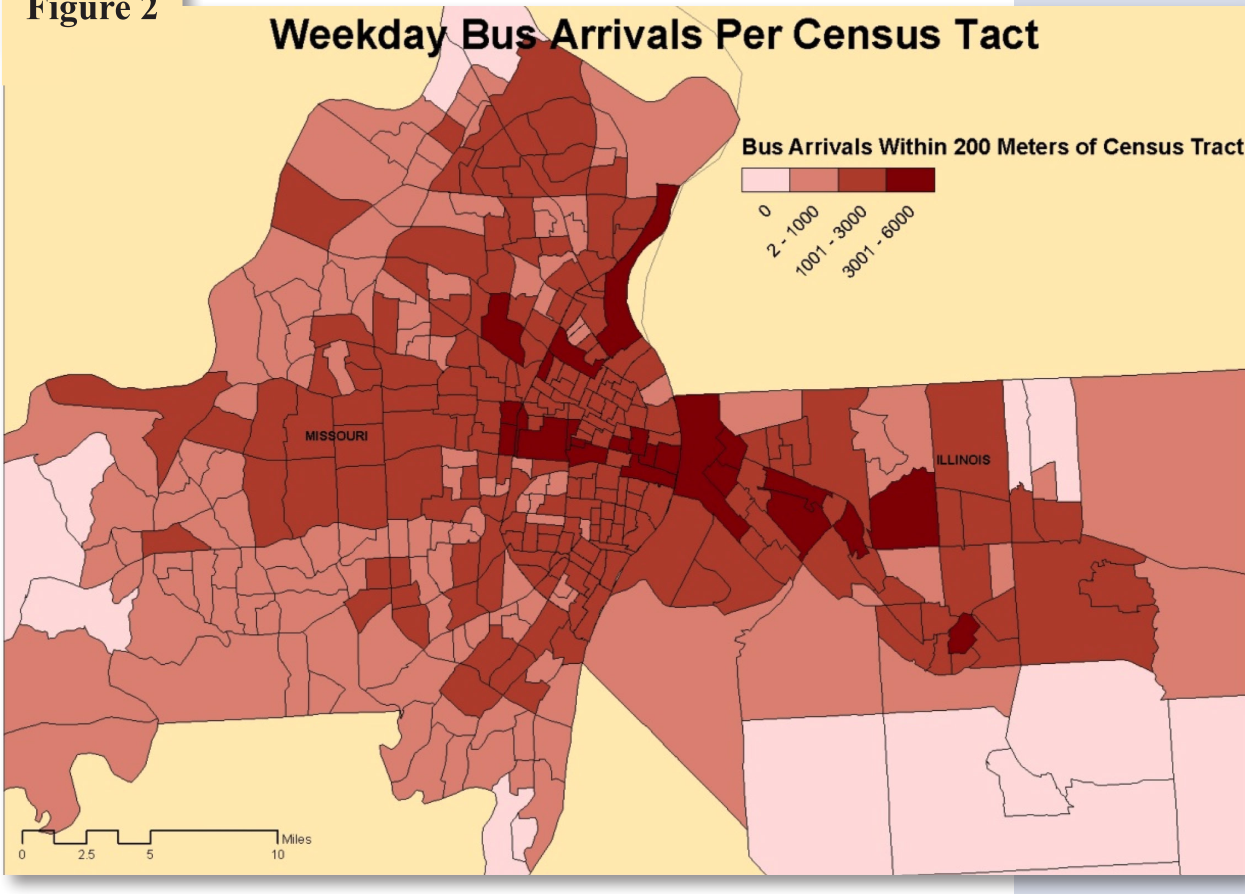

Table 2	Total	Within 400 Meters of Stops	1200 Meters	1 Mile
St. Louis City (square miles)	66.2	52.74	63.62	63.62
% of City		79.7%	96.1%	96.1%
St. Louis County (square miles)	524	148.31	300.81	346.49
% of County		28.3%	57.4%	66.1%
St. Louis City and County (square miles)	590.2	201.05	364.43	410.10
% of St. Louis City and County Covered		34.1%	61.7%	69.5%
St. Clair County/IL (square miles)	674.03	63.56	151.90	191.77
% of St. Clair County		9.43%	22.54%	28.45%
Metro Service Counties (square miles)	1854.43	264.61	516.32	601.87
% of Total Served Counties		14.27%	27.84%	32.46%

Table 3

VARIABLES	**Weekday Bus Stops Per Square Mile**
Population Density (p/square mile)	0.151***
	(0.0177)
Worker Density (p/square mile)	0.109***
	(0.0419)
Median Income	-0.00740***
	(0.00118)
% With No Vehicle Available	54.73***
	(11.49)
Constant	195.7*
	(114.1)
Observations	365
R-squared	0.613
Robust Standard Errors in Parentheses	
***** p<0.01, ** p<0.05, * p<0.1**	

Metro often uses MetroLink stations as hubs from which bus routes radiate. Theoretically, this allows MetroLink to act as a regional transit spine.

transit hubs surrounding MetroLink stations. MetroLink's route takes it to many of the major employment areas in the region, including Saint Louis City's Central Business District, Clayton, Lambert Airport, Barnes-Jewish Hospital, and three major universities.[37] Metro often uses MetroLink stations as hubs from which bus routes radiate. Theoretically, this allows MetroLink to act as a regional transit spine.[38] Figure 3 shows the census tracts with or near MetroLink stops.

What is the effect of MetroLink on bus service? Figure 4 shows the MetroLink line and its stops overlaying bus arrivals inside, or within 200 meters, of a given census tract. In Saint Louis City and Saint Clair County, there is visual evidence that more bus stops are located within census tracts with MetroLink stops, suggesting a vigorous hubbing strategy.

To test the factors that may predict for bus stops, this paper uses the following multiple regression model, which corrects the first model for census tract size and adds in control dummy variables for the tract that contains a MetroLink stop and whether the census tract is in the city:

High FBR stops per square mile per census tract = $ß_1$ *population density* + $ß_2$ *worker density* + $ß_3$ *median income* + $ß_4$ *percent of population with no available vehicle* + $ß_5$ *control* + $ß_6$ *city dummy* + *e*

Figure 3

Figure 4

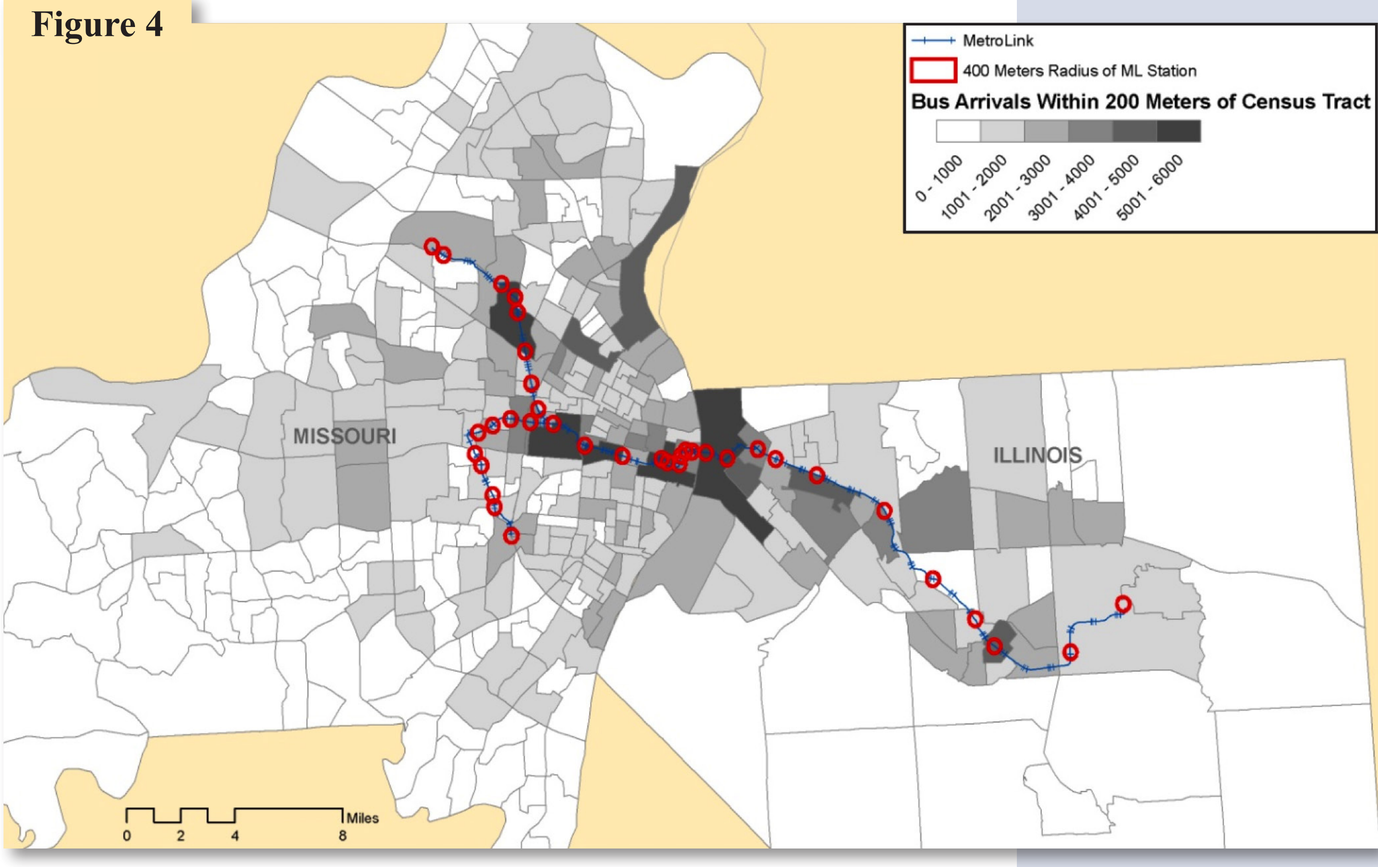

Table 4	(1)	(2)	(3)
VARIABLES	**Stop Density Within 200 Meters of Census Tract**	**Stop Density Within 200 Meters of Census Tract**	**Stop Density Within 200 Meters of Census Tract**
Population Density	0.391***	0.402***	0.301***
	(0.0388)	(0.0386)	(0.0456)
Worker Density	0.153***	0.140**	0.122**
	(0.0562)	(0.0554)	(0.0555)
Median Income	-0.0132***	-0.0127***	-0.0100***
	(0.00229)	(0.00229)	(0.00201)
% No Vehicle Available	129.0***	130.3***	75.91***
	(20.81)	(22.29)	(21.46)
ML Dummy		743.8**	741.3***
		(296.3)	(265.2)
City Dummy			1,344***
			(227.8)
Constant	51.38	-55.56	85.40
	(221.9)	(225.6)	(222.1)
Observations	365	365	365
R-squared	0.667	0.675	0.711
Robust Standard Errors in Parentheses[39]			
***** p<0.01, ** p<0.05, * p<0.1**			

To control for hubbing around MetroLink stations, I used the same model as before but added a MetroLink dummy variable, which turns on (entered as 1) if a station is within the census tract (0 if not), under the assumption that only the hubs completely within a census tract would greatly affect stop locations. Another control variable is a city dummy variable (entered as 1 for all city census tracts and 0 for non-city census tracts), meant to capture any city bias in MetroBus route planning.

The results of this regression are shown in Table 4.

Part III: Factors That Predict for High Ridership and High Farebox Recovery on MetroBus Routes

Description and Visual Evidence

The financial performance of bus routes is tightly intertwined with the levels of monthly ridership. Once the decision is made to run a bus of a certain size, on a certain route, the high fixed costs are built in, and, thus, marginal cost of an additional passenger is nearly negligible. The more passengers a single bus can serve before it is filled to crush capacity, the higher the farebox recovery (fares received as a percentage of route operating costs) that bus will have. As a bus route is made up of many buses running the same distance over the course of a day, farebox recovery will be maximized by high load factors.[40] Load factors can be maximized through steady, high passenger demand or lower cost inputs (i.e., shorter routes, fewer drivers) on routes. Bus routes will have low farebox recovery when demand is insufficient, improperly aligned with bus supply, or the route itself has higher fixed costs. Saint Louis' MetroBus data reflects this accounting; the correlation between monthly bus ridership and farebox recovery ratio is 0.83, indicating a very strong relationship. As such, the actions Metro takes to increase financial efficiency on its bus routes are also likely to be those that increase ridership or decrease fixed costs per route. The close relationship between cost efficiency and ridership reflects Cervero's and other such findings in the literature.

What factors predict for high farebox recovery bus routes or low farebox recovery bus routes? To gain insight on this question, I first looked at how much money MetroBus routes lose per passenger and to what areas of the city these bus routes travel. The financial and ridership performance of Metro's routes varies significantly. While the MetroBus system as a whole averages a weekday farebox recovery ratio of 35 percent in October, the median route FBR is only 25 percent.

As Figure 5 demonstrates, the most common loss is one to two dollars per passenger. However, many routes perform significantly worse than that, with 13 bus routes losing more than eight dollars per passenger.

A visualization of these routes puts these numbers in perspective, with the darker lines representing routes with low FBR and light-colored routes having high FBR. These routes overlay a population density map of Saint Louis City, Saint Louis County, and Saint Clair County. Areas that are redder have high population densities; areas that are more yellow have low population densities.

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Figure 5

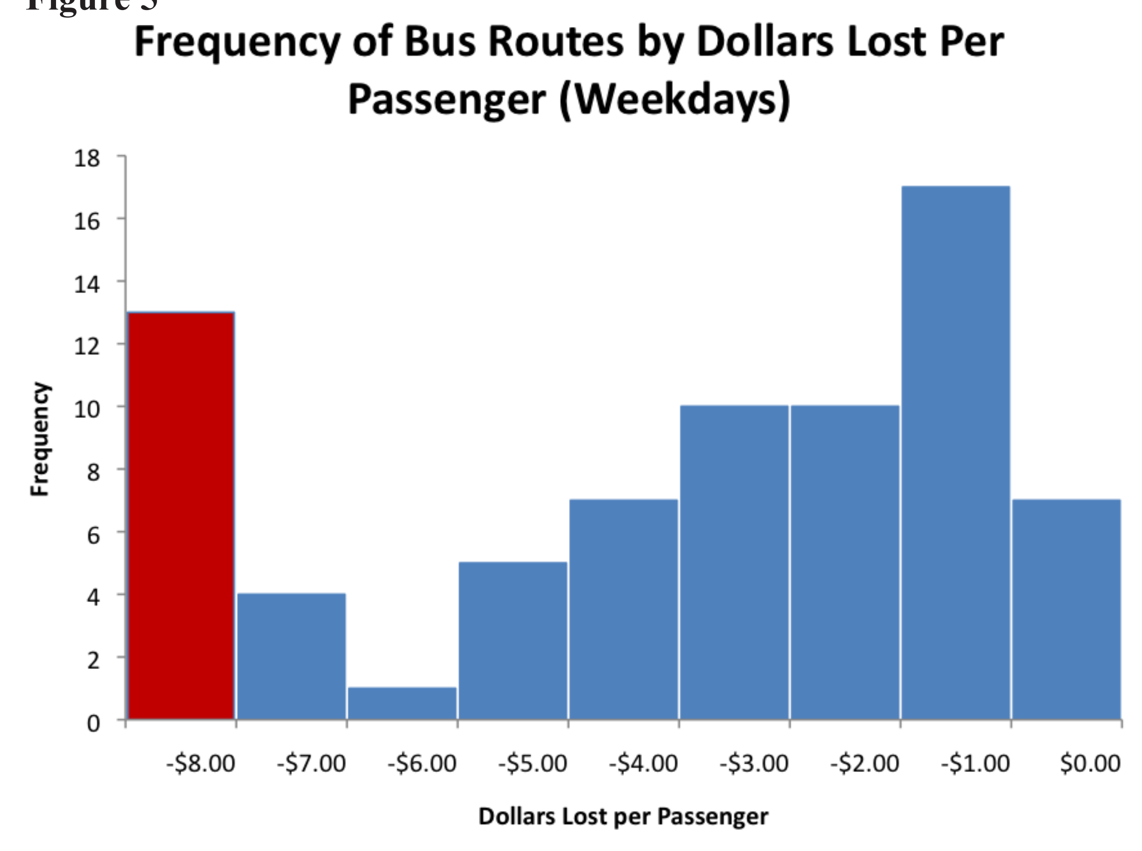


Figure 6

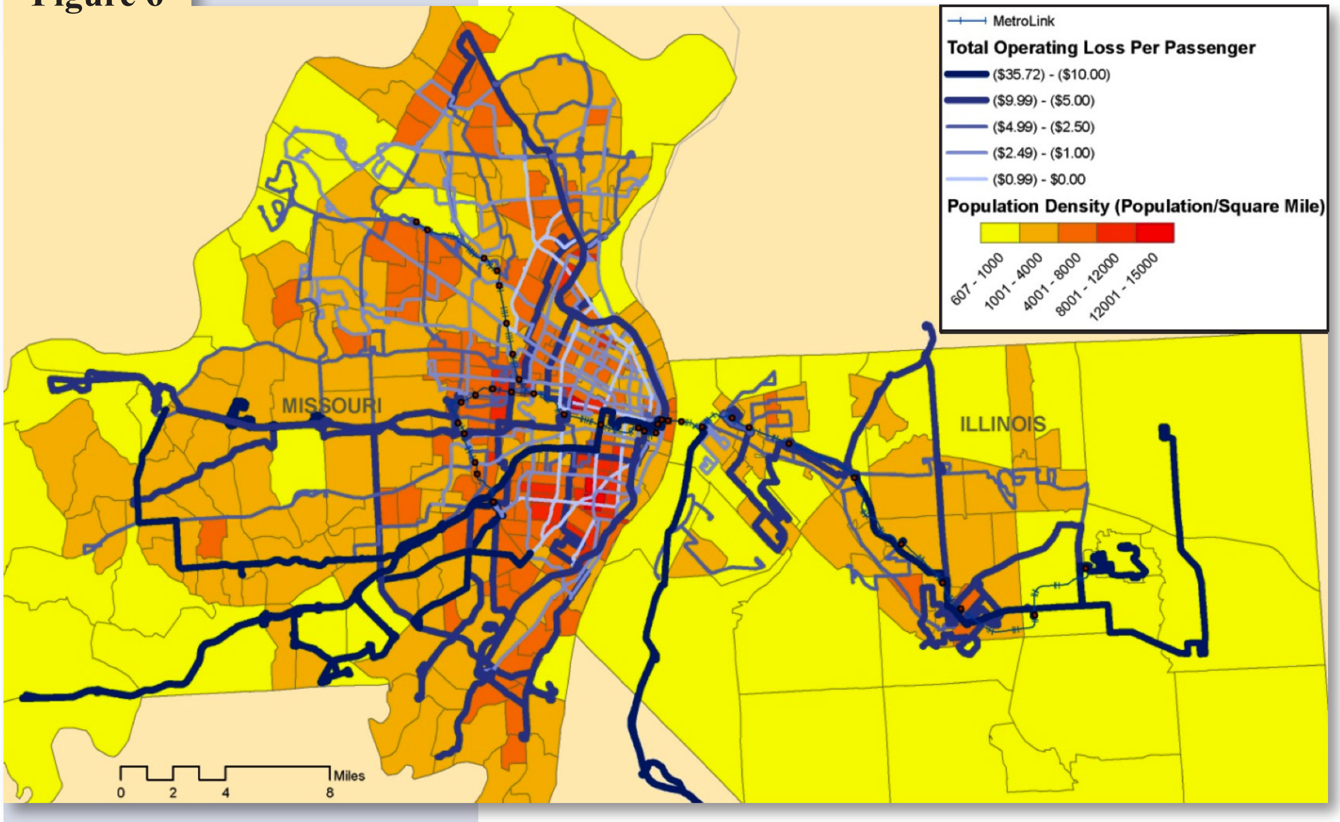


Figure 7

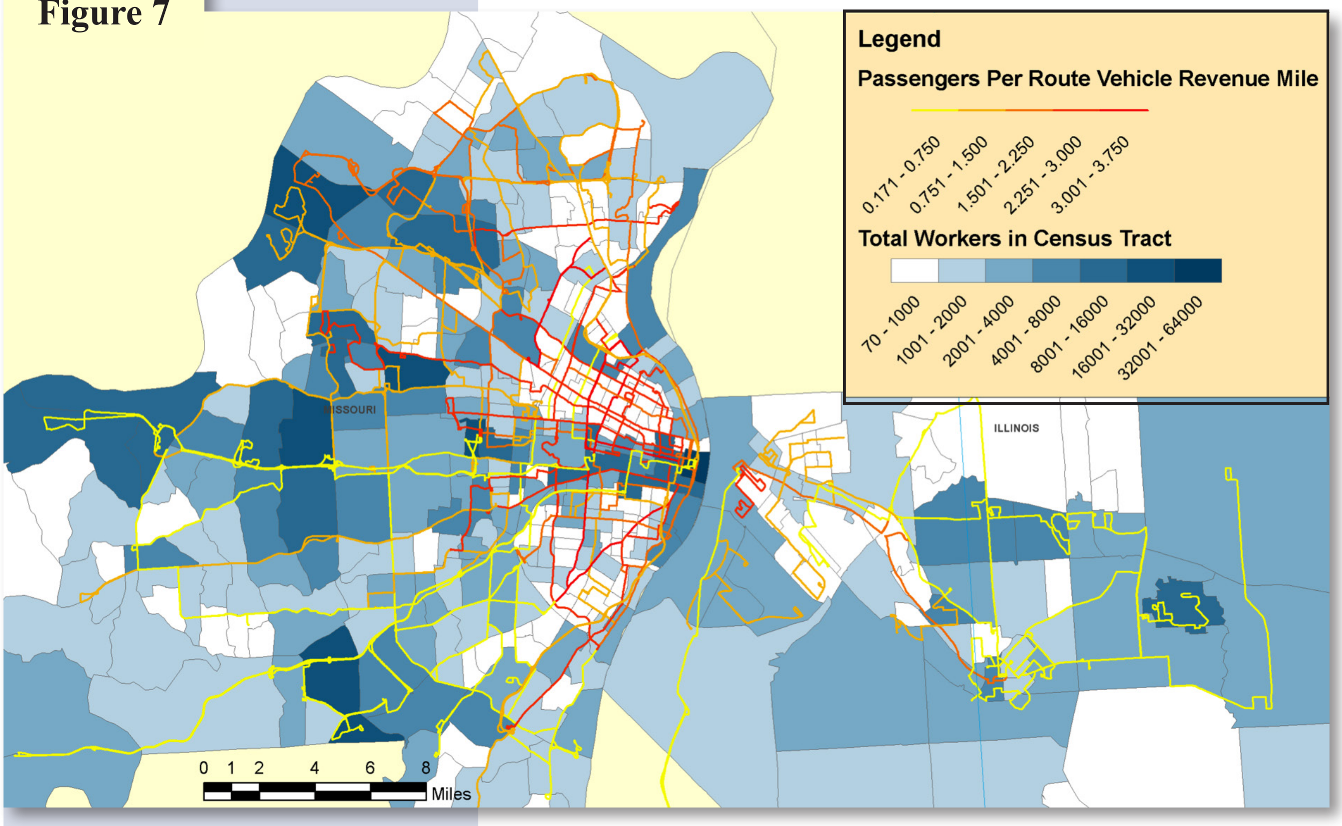


Table 5

Bus Route	FBR
11 Chippewa	81.5%
70 Grand	79.7%
64 Lucas Hunt	67.0%
74 Florissant	65.0%
95 Kingshighway	60.6%
4 Natural Bridge	56.4%
10 Gravois-Lindell	55.8%
61 Chambers Rd	51.5%
18 Taylor	48.7%
90 Hampton	48.1%
32 ML King-Chouteau	45.8%
42 Sarah	44.9%
41 Lee	44.7%
73 Carondelet	44.3%
16 City Limits	43.9%
97 Delmar	43.1%
13 Union	43.1%
94 Page	41.6%
40 Broadway	40.9%
47 North Hanley	39.7%
59 Dogtown	39.4%
35 Rock Road	39.0%
4 19th & Central - ML King	37.3%
30 Soulard	36.1%
21 Watson Rd	34.2%

Figure 7 examines the issue from the perspective of passenger capacity per bus. Lighter color routes have few passengers per vehicle mile, while darker color lines have more passengers per vehicle revenue mile.

Routes with low farebox recovery have few passengers per vehicle revenue mile, which is why Figures 6 and 7 are so similar in terms of high- and low-performing bus routes. Figure 7 also explores the relationship between high-performing bus routes and workplace population. The notion is that areas with high workplace populations should have better financial and ridership performance. The relationship here is less clear on this map than with population density, as many of the more utilized routes run in areas with little or no employment.

While there are no MetroBus routes with revenue that matches or exceeds operating costs, there is a large disparity between different routes' farebox recovery ratios. Table 5 shows the top third of bus routes by farebox recovery ratio.

While there are no MetroBus routes with revenue that matches or exceeds operating costs, there is a large disparity between different routes' farebox recovery ratios.

As Figure 6 demonstrates, the bus routes that lose the most money tend to be long routes that take buses into South and West Saint Louis County or Saint Clair County, while bus routes serving the city and North Saint Louis County perform better. According to Figure 6, there appears to be a positive relationship between the underlying population densities and the performance of overlaying bus routes.

These 25 bus routes have farebox recovery ratios between 34.2 percent and 81.5 percent, meaning they lose between $0.24 and $2.05 per passenger, according to Metro's own calculations (average fare $1.07). While they all carry relatively high numbers of passengers per day, the list is not a perfect representation of the most used MetroBus routes, just the most cost efficient.

Figure 8

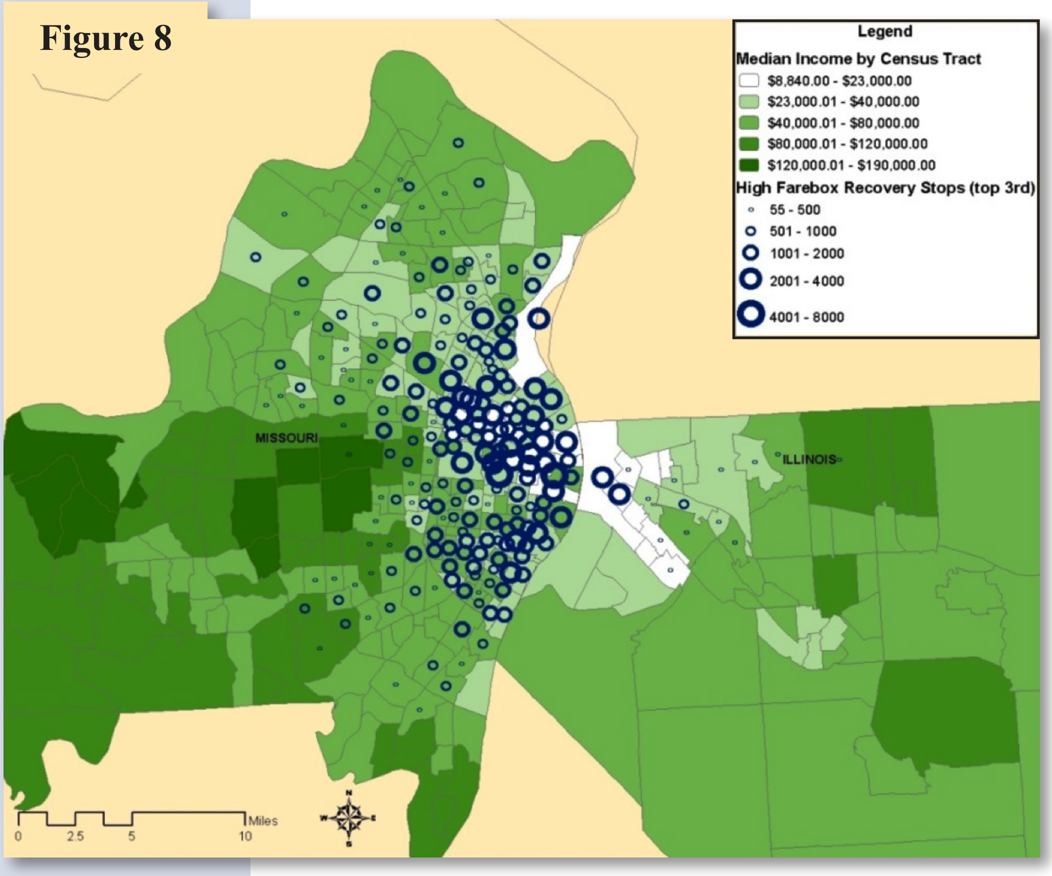


Figure 9

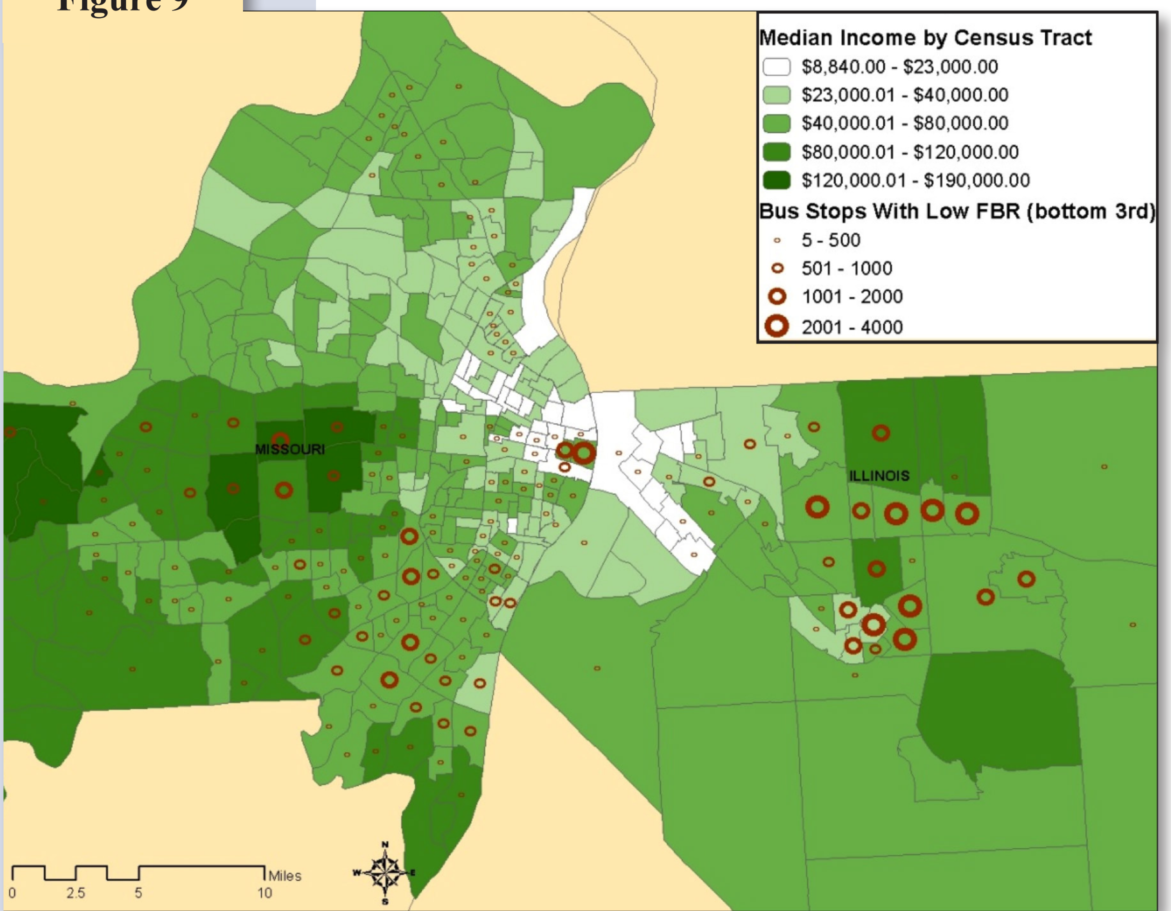


Table 6

Bus Route	FBR
99 Downtown Trolley	18.3%
12 O'Fallon-Fairview Heights	17.8%
16 St Clair Square	16.9%
174X Halls Ferry Express	16.1%
8 Bates-Morganford	15.8%
258 Clayton-Chesterfield	15.8%
58 Clayton-Ballas	15.5%
48 South Lindbergh	13.8%
46 Tesson Ferry	12.9%
15 Belleville-Shiloh Scott	12.4%
13 Caseyville-Marybelle	12.3%
17 Oakville	12.1%
17 Carlyle Plaza-17th Street	11.3%
40X I-55 Express	11.0%
57X Clayton Rd	10.2%
2X Waterloo-Columbia	8.8%
410X Eureka Express	8.3%
210 Fenton-Gravois Bluffs	8.2%
58X Twin Oaks Express	7.7%
158 Ballas-West County	6.6%
21 Scott AFB-Main Base Shuttle	6.4%
110 Affton	5.0%
21X Scott AFB-East Base Shuttle	4.8%
17X Lebanon - Mascoutah	4.7%
12X MetroLink Station Shuttle	2.9%

As Figure 8 shows, bus stops made by high farebox recovery bus routes within 200 meters of all census tracts largely fall into the city and near-north Saint Louis County. More stops also appear clustered in areas of lower income. This evidence is consistent with the notion that the city, and especially poorer parts of the city, contains more high financially performing bus routes.

Many of Metro's bus routes have extremely low farebox recovery ratios. Table 6 is a list of the bottom third of bus routes in terms of cost effectiveness, each less than 20 percent farebox recovery.

The bus routes in Table 6 are the lowest financially performing 25 bus routes for Metro, losing between $4.78 and $37.72 for every passenger. In fact, these bus routes alone lost Metro $1.3 million on weekdays in October of last year. As October is a month where Metro receives its highest ridership, these routes likely lose more than $15 million per year (not including weekends), all to carry fewer riders than the 70 Grand route does alone, which is one of the best-performing routes in Saint Louis with a farebox recovery ratio of 80 percent. While not all of these are the lowest performers in terms of ridership, the resources devoted to these routes far outstrip passengers. These money-losing routes are not evenly distributed around the Saint Louis metropolitan area. As Figure 9 shows, low farebox recovery bus routes are most prevalent in South and West Saint Louis County and Saint Clair County, with the notable exception of the downtown bus hubs.

Figure 9, like the map displaying high farebox recovery bus stops, provides visual evidence that higher incomes are associated with underutilized bus routes. Poorer areas have few, if any, low farebox recovery bus routes while routes to Ladue and

low farebox recovery bus routes are most prevalent in South and West Saint Louis County and Saint Clair County, with the notable exception of the downtown bus hubs.

The visual evidence suggests that high FBR stops are located in areas with high population density, larger percentages of households without cars, lower median incomes, and more workers per census tract.

other wealthy suburbs see few riders. Another explanation that can account for the difference between high FBR bus routes and low FBR routes is whether the areas they serve have low car ownership. Figure 10 displays the high and low farebox recovery stops overlaying the percent of residents per census tract that do not own vehicles.

Figure 10 shows that the dark areas (high levels of no-car households) have many more high FBR bus stops, while low FBR bus stops are clustered in areas with low percentages of households without personal vehicles.

Statistical Analysis

The visual evidence suggests that high FBR stops are located in areas with high population density, larger percentages of households without cars, lower median incomes, and more workers per census tract. Here, I apply statistical models to quantify these relationships. To perform this analysis, bus stops were divided into two cohorts, the stops from the top third of bus routes in terms of farebox recovery and the stops from the bottom third of bus routes in terms of farebox recovery. By running OLS regressions on these cohorts separately (essentially treating them as two different populations), we can quantify some of the relationships between cost-effective/cost-ineffective bus routes and surrounding census tract characteristics. The differences in those relationships can provide evidence on where the operation of buses is likely to predict for cost effectiveness.

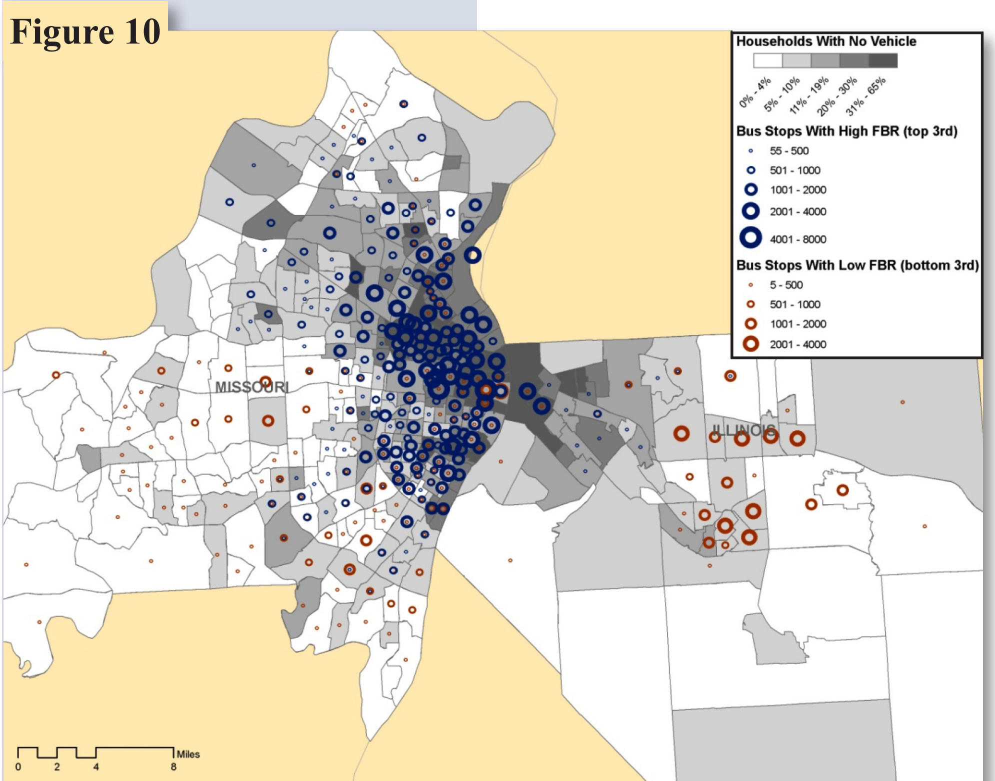
High Farebox Recovery Stops

This section uses OLS multiple regressions with the dependent variable of: number of high farebox recovery bus stops (top third of distribution) in or within 200 meters of a census tract, divided by that tract's area. The regression's equation is as follows:

High FBR stops per square mile per census tract = β_1 *population density* + β_2 *worker density* + β_3 *median income* + β_4 *percent of population with no available vehicle* + β_5 *control* + β_6 *city dummy* + *e*

This equation is very similar to that used in Part 2. The principle difference, aside from the change in dependent variable, is the addition of total weekday stops as an independent variable. This variable, which is simply the total number of weekday stops in a given tract, was included to control for any bus hubs that were not located at a MetroLink station. The reasoning is that census tracts with many stops will have FBR stops simply by having more

Figure 10



stops, so by controlling for simply having many stops we can isolate the impact of demographic predictors on the prevalence of high FBR bus stops. The results of this model are shown in Table 7.

Table 7	(1)	(2)	(3)	(4)
VARIABLES	Top 3rd Farebox Recovery Stops/ Square Mile	Top 3rd Farebox Recovery Stops/ Square Mile	Top 3rd Farebox Recovery Stops/ Square Mile	Top 3rd Farebox Recovery Stops/ Square Mile
Worker Density (p/square miles)	0.0578	0.0701**	0.0811**	0.0526
	(0.0406)	(0.0325)	(0.0319)	(0.0349)
Population Density (p/square miles)	0.382***	0.376***	0.376***	0.245***
	(0.0336)	(0.0317)	(0.0319)	(0.0367)
Median Income	0.000799	0.00105	0.00143	0.00231
	(0.00239)	(0.00235)	(0.00227)	(0.00195)
% With No Vehicle Available	193.3***	193.8***	193.6***	129.6***
	(24.87)	(24.07)	(23.75)	(22.12)
Weekly Bus Stops	0.331**	0.395***	0.487***	0.349**
	(0.130)	(0.143)	(0.144)	(0.144)
ML Dummy		-366.4		
		(233.9)		
ML Stops 400 Meters			-420.2***	-234.7*
			(135.3)	(127.0)
City Dummy				1,643***
				(190.7)
Constant	-1,572***	-1,603***	-1,648***	-1,253***
	(166.7)	(166.2)	(163.7)	(170.7)
Observations	365	365	365	365
R-squared	0.494	0.496	0.510	0.538
Robust Standard Errors in Parentheses				
***** p<0.01, ** p<0.05, * p<0.1**				

The different runs of these regressions have counterintuitive results. Population density and percentage with no vehicle available predict for more high FBR stops. Interestingly, worker population density only significantly predicts for higher farebox recovery stops in two of the four models, meaning that connections with places of high employment does not necessarily predict for more efficient bus routes in this data. In addition, the presence of the MetroLink actually predicts for fewer high farebox recovery stops, contrary to the expectation that intermodal hubs would aid all areas of connecting transit routes. This may be an effect of competition from the light rail lowering the ridership on routes that connect to the MetroLink. However, the MetroLink effect is only significant at the P<.05 level in the third run, when the definition of having a MetroLink stop was widened to include having a MetroLink stop within 400 meters from of a census tract.

Even controlling for worker density, population density, median income, and percentage of household without vehicles, the city dummy still has a very positive and significant prediction for more high FBR bus stops. This may be because of an important omitted variable, the attributes of surrounding census tracts. For instance, a census tract that has high population density may be less likely to have a high FBR stop if surrounding census tracts have low population densities. In this model, it may be that the city dummy variable is capturing the positive effect of an agglomeration of favorable demographic factors for high farebox recovery stops among neighboring census tracts. To conclude, the evidence suggests, much in line with the literature, that census tracts located in the city with high population densities and low car ownership predict for more cost efficient bus routes.

Low Farebox Recovery Stops

The same models used previously were run using the dependent variable of: low FBR stops (less that 15 percent FBR) in or 200 meters from census tracts divided by census tract area. The equation:

Low FBR per square mile per census tract = β_1 *population density +* β_2 *worker density +* β_3 *median income +* β_4 *percent of population with no available vehicle +* β_5 *control +* β_6 *city dummy + e*

Using the same reasoning as with high farebox recovery stops, with mirrored expectations, I created four different models. The results are shown in Table 8.

Table 8	(1)	(2)	(3)	(4)
VARIABLES	Low 3rd Farebox Recovery Stops/ Square Mile	Low 3rd Farebox Recovery Stops/ Square Mile	Low 3rd Farebox Recovery Stops/ Square Mile	Low 3rd Farebox Recovery Stops/ Square Mile
Worker Density (w/square miles)	0.0304**	0.0287**	0.0324**	0.0312**
	(0.0125)	(0.0121)	(0.0137)	(0.0139)
Population Density (p/square miles)	0.00690	0.00777	0.00634	0.000703
	(0.00756)	(0.00718)	(0.00751)	(0.00908)
Median Income	0.000972	0.000937	0.00103	0.00107
	(0.000657)	(0.000661)	(0.000674)	(0.000671)
% With no Vehicle Available	-13.27***	-13.33***	-13.25***	-16.00***
	(4.119)	(3.986)	(4.182)	(4.851)
Weekly Bus Stops	0.154***	0.145**	0.168**	0.162**
	(0.0592)	(0.0615)	(0.0652)	(0.0682)
ML Dummy		50.45		
		(84.26)		
Density ML Stops			-37.67	-29.68
			(43.43)	(46.17)
City Dummy				70.77
				(63.01)
Constant	-36.82	-32.52	-43.61	-26.61
	(85.79)	(86.62)	(87.76)	(95.22)
Observations	343	343	343	343
R-squared	0.295	0.298	0.299	0.303
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

These results are somewhat surprising when compared with the high farebox recovery stop results. Population density and percentage of households with no vehicle are not significant. Another surprising result is that worker population density predicts positively for low farebox recovery stops. This is counterintuitive, especially as the literature and the actions of Metro would presume this to be a positive relationship. An explanation may be that Metro, in attempting to maximize utilization of its resources, supplies more bus resources to high employment centers despite a lack of passengers (such as employment centers in Saint Louis and Saint Clair County) leading to overall poor performance of routes in those census tracts. Much travel is not commuting and it may be that Metro is overemphasizing commuting bus routes over general metropolitan area connectivity.[41] The MetroLink had no significant predictive power for the presence of low farebox recovery stops, nor did the city dummy predict for more or fewer low farebox recovery bus stops. The results suggest that census tracts with higher workplace population and higher car ownership predict for more low farebox recovery bus stops.

Limitations of the Data

The scope of this study is limited, and more data and statistical analysis is required to discern all factors that make a bus route successful. The data's limitations include:

- Financial and passenger level data is route level only. There is no way to see where passengers board and alight. This means that successful bus routes will appear successful all along the route in this data, when a route's popularity is likely heterogeneous. The same is true vice versa for low-performing bus stops.

- Instead of using a continuum for financial performance, the analysis above breaks buses into high-performing and low-performing stops and made the count of those stops the dependent variable for analysis. A further study could explore the results using a continuous rather than dummy variable for high and low FBR bus stops, especially if the unit of analysis becomes the route and not the census tract.

- As was stated previously, there was no way to tell the dynamic performance of bus routes over the entire route or the dynamic effect of moving between census tracts. A further study that made the route, and not the stops within the census tract, the unit of analysis would be useful.

- Census tracts vary in size and may contain heterogeneous demographic areas that bias the results. For instance, a large census tract may have a high median income while median income around the bus routes is actually low.

- Results of what contributes to high FBR stops was not inverted for low FBR stops, indicating that an increase in data sample size may further change or refine results.

Note on endogeneity: It is possible that the results of regression are endogenous, such that bus route stops with higher ridership cause higher population and workplace density. Studies have shown that rapid transit systems often create higher density and higher property values. However, this is unlikely in the case of the Saint Louis bus system for many reasons. First, the development patterns in the city predate existing bus routes. Second, population and workplace densities are usually decided by zoning, which is generally not altered or dictated by the existence or non-existence of bus routes, as they

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might be to create transit-oriented development around rapid transit stops. Third, many areas of the city that historically had the highest passenger levels (North Saint Louis, North Saint Louis County) have actually lost population density and workplace population. At the same time, population and employment has rapidly increased in areas with little bus users. Hence, although there may be joint determinacy between bus route efficiency and demographic factors, it is very likely that the dominant relationship is demographic factors predicting for route efficiency.

Conclusion

According to Metro's own statements, the bus system is designed to be a hub and spoke system that disproportionately serves low-income, high-population areas in Saint Louis City with the emphasis on improving workplace connectivity. The data in this paper supports these statements. However, most of Metro's bus routes carry passengers well below capacity, leading to high operating deficits per boarding. Metro may be able to improve its efficiency if it devoted its resources to areas that are more likely to result in higher ridership and higher farebox recovery, and away from areas with low ridership and low farebox recovery. This paper shows that city census tracts with low car ownership and high population density predict for better cost-effectiveness. These findings match those made by Cervero, with the exception that this essay does not contain evidence that workplace population density predicts for more cost-effective routes. Additionally, from an equity perspective, these areas are also the most financially distressed in the metropolitan area.

South and West Saint Louis County and most of Saint Clair County are likely not ideal places to devote Metro's finite resources. For political and practical reasons, it is likely not possible to simply end service to areas that have low levels of bus service and low farebox recovery.

However, Metro could take the following approaches to improve cost efficiency (i.e., to reduce its low farebox recovery routes and to increase high farebox recovery routes):

- Reduce cost structure. Tactics may include:

    1. Reduce total service on low farebox recovery stops.

    2. Reduce the size of buses serving low farebox recovery stops. Metro's smallest buses are far more than what is required for the least-used bus routes, and using small vans to reduce pickup times would save money and allow buses to be redeployed.

    3. Encourage car/van share. With very low numbers of individuals using routes from the city to South Saint Louis County and Saint Clair County, Metro might cut routes while facilitating van-share or ride-share systems as a reasonable replacement for the few who truly require non-personal vehicle travel. Van-share programs are among the most cost-effective public transportation

systems nationwide and can complement more heavily used bus routes.[42 43] Currently, Metro does not prioritize car sharing, and the only regional service is coordinated out of Madison County, Illinois.

- Redeploy resources to areas that predict for more ridership. The system might be better deployed if it did not have to serve areas with high car ownership as well as low population densities in Saint Louis County and Saint Clair County. Metro could leave it to more distant localities to privately provide more efficient bus service in areas further from Saint Louis City, as is already the case in Saint Charles County. This would allow Metro to create a more efficient system centered on areas with higher ridership and farebox recovery. Independence, Missouri, could be a model here.

A more cost-effective transportation system might be able to better focus its resources so that MetroBus can be more reliable and useful in the places where a bus system can work well, while implementing adequate service to those without cars but with jobs in the outer suburbs. While none of the solutions listed previously would be easy to implement politically or practically, a well-functioning, financially sustainable bus system will reap benefits far into the future both for the users of the system and the taxpayers that provide additional funding.

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