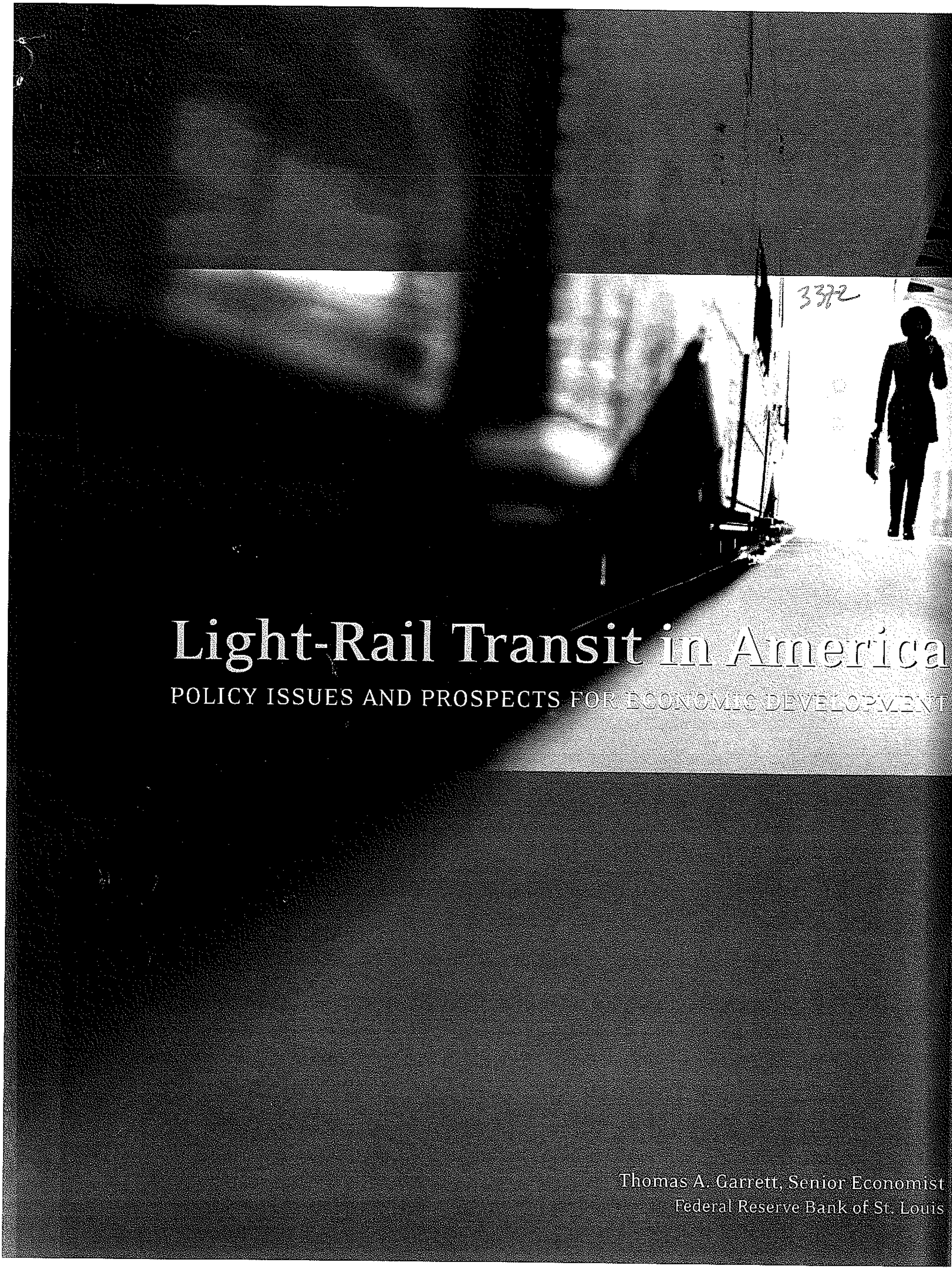

Light-Rail Transit in America

POLICY ISSUES AND PROSPECTS FOR ECONOMIC DEVELOPMENT

Thomas A. Garrett, Senior Economist
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August 2004

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Preface

Light-rail systems have become a common fixture in many American cities over the past several decades. This report discusses the policy issues surrounding light-rail transit and provides evidence on the ability of light rail to foster economic development. The information should prove useful to local officials, policy-makers and the public, all of whom may be involved in a debate over the implementation or expansion of light-rail transit. These issues are discussed through the lens of an objective economic analysis. An examination of the policy issues using other lenses is beyond the scope of this analysis.

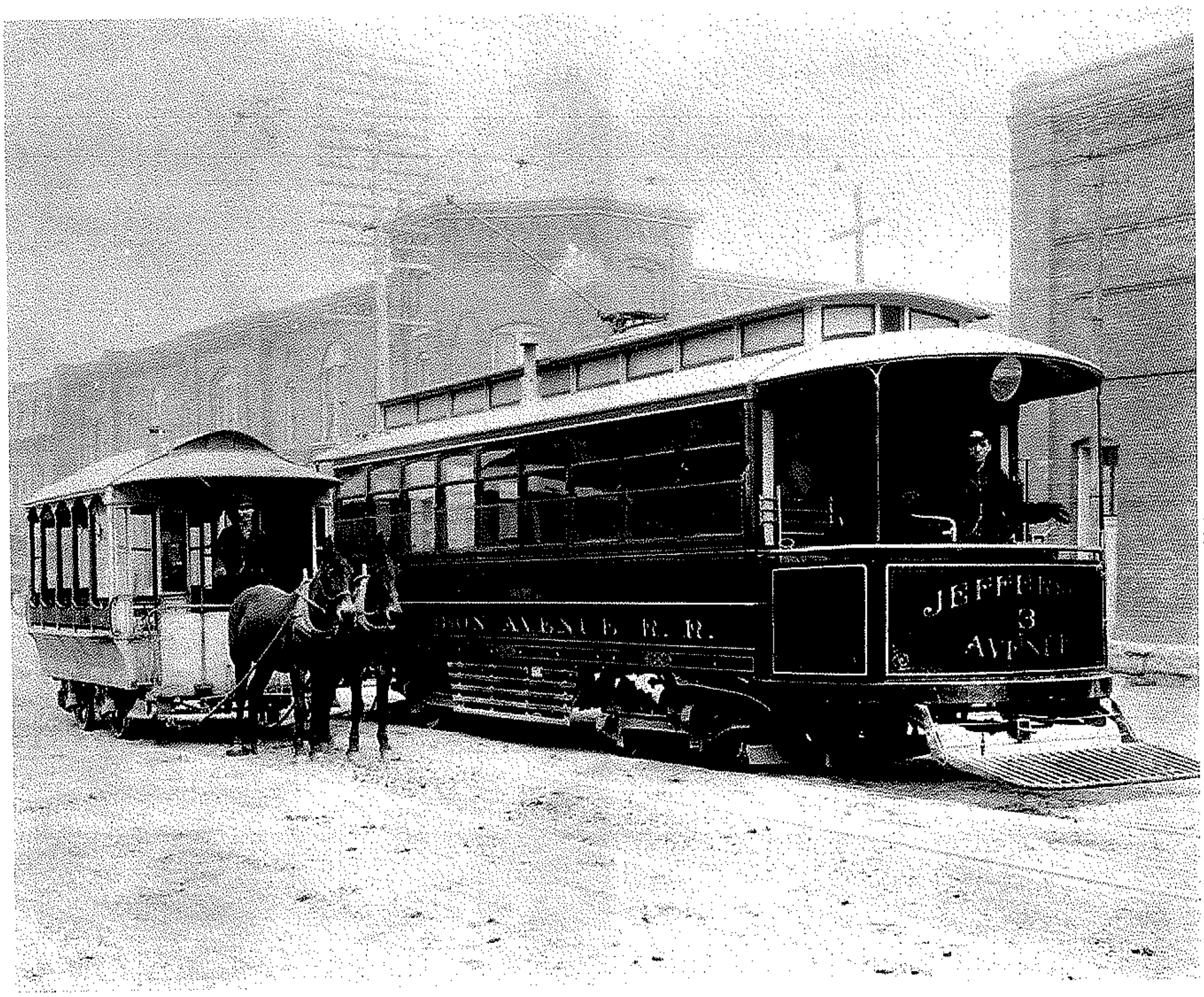
The report begins by providing a history of light rail in America. The historical discussion spans the early 1800s to the present. Both a general overview and detailed statistics on several light-rail systems in the United States are also presented. This section will give readers a basic understanding of the history and scope of light-rail transit.

The next section of the report examines five key issues that often arise in the light-rail debate. The issues are job creation, citizen preferences for rail vs. car, air pollution, traffic congestion, and solvency and cost efficiency. Proponents also argue that light rail is a primary means of transportation for a city's poorer residents. Although this is an important benefit of light rail, few people may realize the actual cost of providing this transportation. This report reveals the cost of light-rail subsidies for the poor, using a numerical example that compares the cost of light-rail transit with that of car ownership. The discussion also provides numerous statistics and references for those readers wishing to obtain further information on specific issues covered in this section.

The ability of light rail to foster economic development and improve property values is covered in the next section of the report. The academic literature on the subject is reviewed, and the conditions in which light rail may lead to economic development are outlined. Understanding these conditions is crucial for any effective policy decision regarding the creation or expansion of light rail. The topic of transit-oriented development is then discussed. This, too, is a subject that all who are involved in the light-rail policy debate should fully understand.

The fifth section of the report contains an empirical analysis of the MetroLink light-rail system in St. Louis. Specifically, the analysis looks at the effect of MetroLink on residential property values in St. Louis County. To date, there has been no formal economic analysis of MetroLink's effect on property values. The findings and their policy implications are discussed.

The final section is reserved for concluding comments and a summary of the report's major issues and findings.



Light-Rail Transit in America: Policy Issues and Prospects for Economic Development

I. Introduction

More than 50 cities in the United States currently provide rail transit as a means of regional public transportation. Regional rail systems in America logged more than 900 million vehicle miles and 24 billion passenger miles in 2002.[1] In comparison, bus service nationwide amassed 1.8 billion vehicle miles and 19.5 billion passenger miles, and private automobiles logged 1.6 trillion vehicle miles and 2.5 trillion passenger miles. Each day, millions of commuters, tourists and students rely on regional rail transit as their primary source of transportation, and dozens of metropolitan areas across the country see rail transit as a form of public transportation that can encourage economic development in the local area.

Regional rail systems vary greatly in their design, ranging from single-car trolleys running at street level to multicar trains operating on extensive networks of elevated tracks and subway systems. There are three types of regional rail transit: heavy rail, commuter rail and light rail.[2] Many American cities have more than one of these forms of rail transit. Table 1 provides information on the types of rail transit in selected U.S. cities.

Table 1–Selected Rail Transit Cities

Metropolitan Area	2000 Population[a] (millions)	Rail System(s)
Atlanta	4.11	Heavy
Baltimore	2.55	Heavy, Light
Boston*	3.40	Heavy, Light, Commuter
Charlotte, N.C.*	1.50	Light
Chicago	8.27	Heavy, Commuter
Cleveland	2.25	Heavy, Light
Dallas	3.52	Light
Denver*	2.11	Light
Detroit*	4.44	Light
Los Angeles	9.52	Heavy, Light, Commuter
Memphis, Tenn.*	1.14	Light
Miami	2.25	Heavy, Commuter
Minneapolis*	2.97	Light
New Orleans*	1.34	Light
New York City	9.31	Heavy, Commuter
Philadelphia*	5.10	Heavy, Light, Commuter
Pittsburgh	2.36	Light
Sacramento, Calif.	1.63	Light
St. Louis	2.60	Light
San Diego*	2.81	Light, Commuter
Seattle*	2.42	Light
Washington, D.C.	4.92	Heavy, Commuter

Source: Light Rail Transit Association (www.lrta.org/index.html#top) and city transit web sites.
** All or part of the city's light-rail system consists of trolleys or streetcars.*
[a] Population is for the Primary Metropolitan Statistical Area (PMSA) and comes from the U.S. Census.

Heavy rail refers to high-platform subway and elevated transit lines. New York City, Boston, Philadelphia and Chicago are several cities that have heavy rail. These systems operate on tracks that are completely segregated from other uses. The trains consist of anywhere from two to 12 cars and draw power from a third rail or overhead electrical wires. Unlike light rail and commuter rail, heavy rail is relatively more expensive to build, given the need for subways and elevated platforms and tracks. Heavy rail systems nationwide logged more than 13.5 billion passenger miles and collected nearly $2.3 billion in fare revenue during 2002, more than commuter rail and light rail combined. (See Table 2).

Commuter rail operates on main-line railroad tracks to move passengers between suburbs and city centers. These systems can be found in Philadelphia, Los Angeles, New York City and Boston, to name a few. Commuter trains generally consist of a locomotive and several passenger cars. Commuter rail can extend up to 50 miles beyond the city center, which is much farther than heavy-rail systems. However, commuter systems operate less frequently (one train about every 30 minutes) than heavy rail and may not operate at all on weekends. Commuter rail is usually cheaper to build than heavy rail because it operates on existing railroad tracks. However, careful planning with freight train schedules is needed to ensure safe negotiation of the shared track. Commuter rail generates 9.5 billion passenger miles and $1.5 billion in fare revenue annually.

There are two types of *light-rail* systems. The first system involves light cars, sometimes called trolleys, trams or streetcars, which run along the street and share space with motor vehicles. Such systems exist in San Diego (in part), New Orleans and Charlotte, N.C. The second light-rail system consists of multicar trains that operate along their own right of way and are separated from roadways. St. Louis; Portland, Ore.; Pittsburgh; San Jose, Calif.; and Buffalo, N.Y., all have this second type of light-rail system. Combined, these two systems logged 1.4 billion passenger miles and amassed $226 million in fare revenue in 2002, which is significantly less than heavy rail and commuter rail. All light-rail systems are powered by electricity, provided by either an overhead wire or a third rail. Unlike heavy rail and commuter rail, some light-rail systems are automatic, thus eliminating the need for an operator. Many light-rail systems in the United States use parts of abandoned rail networks. Also unlike heavy rail and commuter rail, light-rail systems are generally cheaper to build and have a greater ability to maneuver sharp curves and much steeper grades.

Adoption of Rail Transit

Modern heavy- and commuter-rail transit systems started appearing in the United States in the early part of the 20th century, whereas modern light-rail systems did not make their debut until the late 1960s. Although a more detailed history of these three rail systems is given later in this report, it is interesting to note that the timing of each system's adoption was motivated by two different issues.

Heavy-rail systems in cities like New York and Chicago were born out of necessity. Rapid population growth and the resulting traffic congestion beginning in the early 1900s made practical travel into these city centers nearly impossible. Roadways were still tailored for horse-drawn carriages, and the rapid increase in automobile use was taxing the capacity of city streets. Heavy- and commuter-rail systems were seen as a solution to the congestion problem.

The development of modern light-rail systems has been motivated by their potential to not only alleviate traffic congestion but to foster economic development. Just like New York

Table 2–Summary Statistics for Various Forms of Transit

Form of Transit	Vehicle Miles (millions)	Passenger Miles (millions)	Operating Expenses (millions $)	Fare Revenue (millions $)
Public Transportation				
Heavy Rail	603.5	13,663.2	4,267.5	2,294.5
Commuter Rail	259.1	9,449.8	2,994.7	1,448.5
Light Rail	60.0	1,431.1	778.3	226.1
Bus	1,863.8	19,526.8	12,585.7	3,731.1
Private Transportation				
Auto	1,619,395.0	2,574,882.0	—	—

Note: See Endnote 1 in text for data description and sources. Public transportation data are for 2002, and auto data are for 2001.

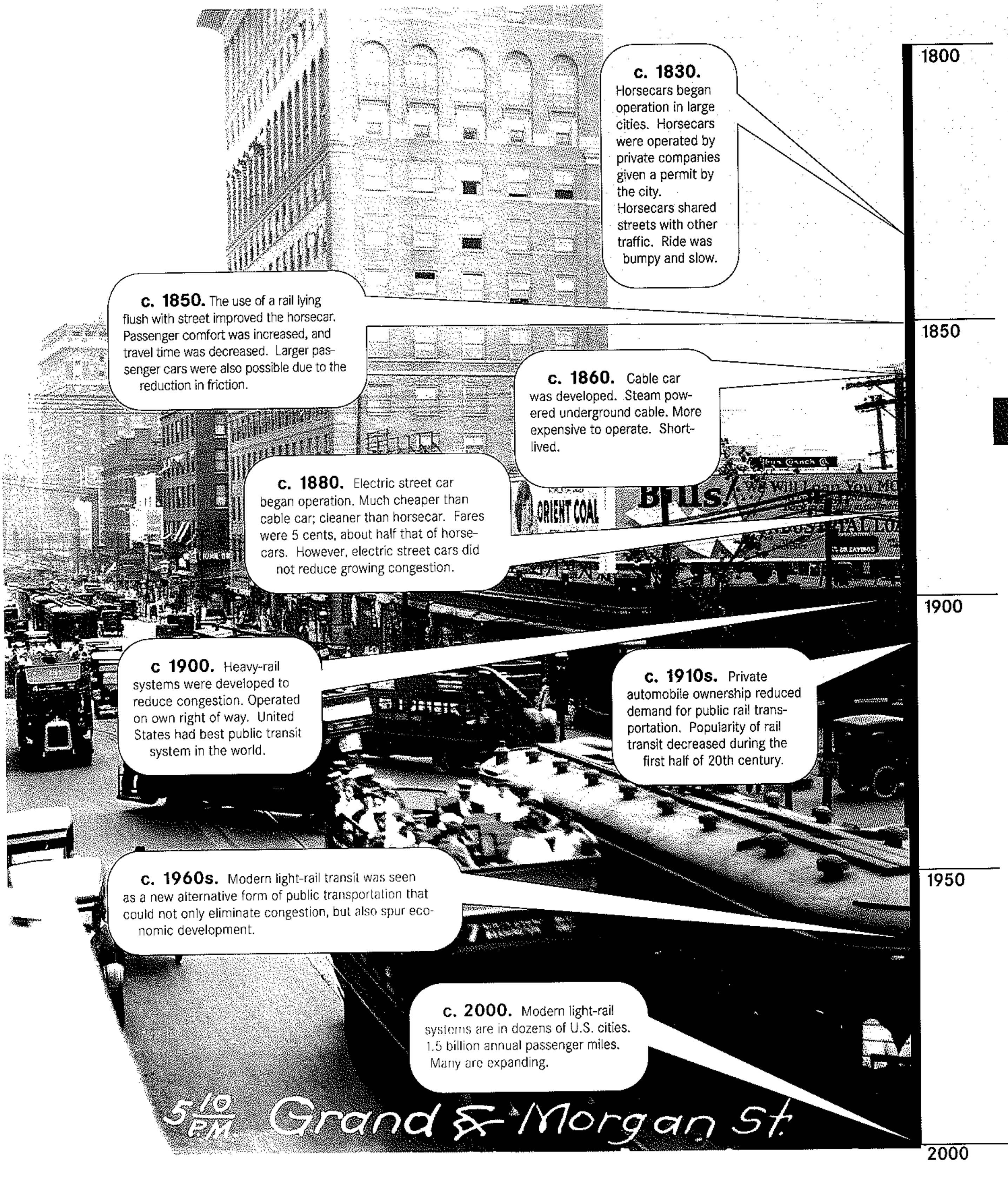
and Chicago in the early 1900s, midsized American cities began experiencing growing traffic congestion in the post-World War II era. However, the rapid growth in city suburbs and a more environmentally conscious public led officials to realize that light-rail systems might not only help alleviate traffic congestion and pollution but that strategically placed light-rail systems might also enhance economic development around light-rail stations.

The idea that rail transit can promote economic development with the cooperation of city officials and private developers is known as transit-oriented development (TOD). Although TOD is one goal of any public transportation system, officials see light rail as a particularly amenable tool for spurring economic development. As suburbs continue to grow outward from city centers, more officials and economic developers are looking for ways to spur the growth of city centers and to restore them as the focus of the metropolitan area. TOD and light-rail transit will be discussed in greater detail later in the report.

II. History and Scope of U.S. Rail Transit Systems

History of Rail Transit in the United States

The origins of rail transit and other forms of public transportation can be traced back to the early 1800s.[3] At that time, public transportation consisted of horse-drawn covered carriages, often referred to as horsecars.[4] The first horsecar service in the United States began in New York City in 1829 and soon spread to Philadelphia in 1831, Boston in 1835 and Baltimore in 1844. Horsecar service was run by private businessmen who were given the exclusive right to operate by the city. Although horsecar service was slightly faster than walking, the unpadded benches, bumpy cobblestone streets and minimal insulation from the weather often made for an unpleasant ride. In addition, horsecars had to share scarce street space with existing pedestrian and



carriage traffic rather than having their own right of way.

Placing horsecars on rails was the next improvement in public transportation, and, as a result, this became the earliest form of light-rail transit in the United States. The use of rails made for a smoother and faster ride, and the rails provided more of a right of way for the horsecars. The reduction in friction afforded by placing the horsecars on rails allowed a single horse to pull a carriage with 30 passengers, more than double the maximum load without rails.

Initially, the biggest problem with the rails was that they were placed on the street rather than embedded in the pavement, thus sticking up several inches and providing obstacles for other street traffic. However, a rail that lay flush with the pavement was developed in the 1850s.

The reduction in friction, larger passenger capacity and increased speed all lowered the operating cost of the horsecar. As a result, fares dropped from about 15 cents per trip to 10 cents per trip.

This decrease in fare, coupled with improvements in the horsecar, led to a significant increase in the number of horsecar systems in the United States. By the 1880s, there were more than 400 street railway companies that operated on 6,000 miles of track. The horsecars carried 180 million passengers per year.[5]

It is interesting to compare light-rail fares in the late 1800s with current fares. On average, light rail today costs about $1.25 to $1.50 per ride, one way. Comparing these nominal dollar amounts suggests that light-rail fares increased about 10 times during the past 150 years or so. However, once inflation is taken into account, a fare of 10 cents in 1870 is equal to $1.61 in 2003 dollars.[6] Thus, light-rail fares today are actually cheaper than fares in 1870 ($1.25 or $1.50 vs. $1.61).

The next advance in public rail transportation was the cable car. Developed in the 1860s, cable cars were very similar to horsecars, but cable cars' power came from large steam engines that moved an underground cable. Cable cars, however, were much more expensive to operate than horsecars. As a result, cable car operations were limited to the most heavily traveled routes in order to recoup the cost of such systems. Given the cost of operating cable cars, these systems were soon replaced with traditional horsecar rail systems.

Electric streetcars began appearing in U.S. cities during the 1880s. These cars resembled modern-day trolleys, with their power coming from overhead electric cables. Electric streetcars were cleaner than horsecars and were much faster, obtaining speeds of 15 mph. In addition, the cost of electric streetcars was lower than horsecars and cable cars because electric streetcars did not require investment in underground cable systems or large numbers of horses. The average fare on an electric streetcar was about 5 cents (81 cents in 2003 dollars), compared with 10 cents ($1.61 in 2003 dollars) for the horsecar.

Despite improvements in public rail transportation through the 1800s, none of these systems was able to eliminate a growing problem in America's cities—congestion. This was in part because horsecars, cable cars and electric streetcars all operated among other roadway traffic. A separate right of way for rail transit was the attempted solution in America's largest cities.

Elevated trains and subways were the first heavy-rail systems in the United States that operated along their own right of way. The first subway opened in Boston in 1897. New York City's elevated train began operations in 1870, and its subway systems opened in 1904. New York City's subway was the first in the world to have an integrated express and local transit system.

Although public rail transportation in the United States was the best in the world at the beginning of the 20th century, the invention of the automobile and its affordability to the average person in the 1910s reduced the demand for public rail transportation. As a result, ridership and public funding for rail systems declined throughout the first half of the 20th century.

Rail public transit was revitalized in the 1960s. As more American cities began to experience increased traffic congestion and pollution, transit experts once again turned to rail as a possible cure. Light-rail systems were seen as a way to remedy congestion and pollution, as well as a means to create economic development in conjunction with careful city planning. This focus on transit-oriented development and the interest of public officials and citizens have all contributed to a rebirth of rail transit in American cities that continues to this day and is likely to persist into the future.

An Overview of Selected Light-Rail Systems

Light rail in the United States ranges from relatively simple trolley systems operating on a few miles of track (Memphis, New Orleans) to multitrain systems operating on dozens of miles of track (St. Louis, Portland). Combined, these light-rail systems annually amass 60 million passenger miles, have nearly 25,000 vehicles in maximum service and generate operating costs of nearly $800 million. This section of the report provides general information on funding the construction and operation of light-rail systems, as well as detailed descriptive statistics for eight light-rail systems in the United States. Because costs, especially operating costs, are an important aspect of public transportation, these are used to make some general conclusions regarding the relationship between light-rail operating cost and service area size.

The capital cost of light-rail construction is funded by various means. Many cities issue bonds to partly or fully cover the cost of construction. These bonds are then financed with earmarked tax revenues (usually sales taxes) that are approved by voters prior to the construction. In many cases, if voters reject local tax increases, the rail project is abandoned.

Although bonds are a popular method of generating capital investment in light rail, other options are available. City officials may require local developers to contribute toward the construction of the system if the developers are expected to profit from development around the light-rail stations. In addition to issuing bonds, cities can also apply for federal or state grants for the construction of light-rail systems. Sometimes these grants are conditional upon a matching contribution from the locality. Private contributions are another method used to pay for construction of light-rail systems. In some cities, businesses pay money in return for the right to advertise on train cars.

The operating cost is that arising from the day-to-day operation of rail transit. This cost includes maintenance, operator and administrative salaries, and materials and supplies. Of these, salaries account for the largest component of the operating cost. Revenue to cover light rail's operating cost is obtained from various sources. Local, state and federal funds cover roughly 60 percent to 70 percent of the operating cost. At the local level, a portion of sales tax revenue from a voter-approved tax increase is used to help pay the operating cost. State and federal grants are also used. Fares account for the remaining revenue (about 30 percent) that is used to cover the operating cost. Clearly, a significant portion of light rail's operating cost is covered with subsidies and not fare revenue.

Detailed statistics on eight light-rail systems in the United States are shown in Table 3. The rail systems in Table 3 are a representative sample of the numerous systems operating across the country. All data are from the Federal Transit Administration's National Transit Database and are for the year 2002.

Data are provided on the operating cost, fare revenue and subsidies (operating cost minus fares). The subsidy is equivalent to the tax cost to society.[7] Also included is information on passenger miles (the sum of miles traveled by all passengers in a given time period) and vehicle miles (the total mileage traveled by all vehicles of a particular type in a given time period). Operating cost per passenger mile and operating cost per vehicle mile also are presented to show the cost efficiency and service efficiency, respectively, of each light-rail system. Data are provided on size in square miles, population density, service area population and fare revenue as a percent of the operating cost.

The data in Table 3 reveal marked differences in the cost structure of light-rail systems. Although there are differences in fare revenues, operating expenses and operating subsidies across systems, it is hard to accurately compare these statistics given differences in the size of each light-rail system and area served. To better compare each system, the operating cost is usually computed on a per-passenger-mile basis and on a per-vehicle-mile basis. A passenger mile is a measure of ridership (quantity of riders and distance traveled), and a vehicle mile is a measure of service size and frequency of travel. So, light-rail operating cost per passenger mile is a measure of cost-effectiveness, and operating cost per vehicle mile is referred to as a measure of service efficiency.[8] Both are valid methods of comparison, but it is important to realize that they each measure a different aspect of light-rail operations.

Of the eight light-rail systems in Table 3, the systems in St. Louis and Portland have the lowest operating cost per passenger mile (27 cents and 34 cents, respectively), whereas Philadelphia and Buffalo have the highest (78 cents and $1.04, respectively). Denver and St. Louis have the lowest operating cost per vehicle mile ($6.38 and $6.60, respectively), while Philadelphia and Buffalo have the highest ($14.01 and $17.58, respectively). There is a positive, but not perfect, correlation between cost per passenger mile and per vehicle mile.

Light-rail systems also differ greatly in terms of the percentage of operating expenses covered by fare revenue. This statistic reveals how closely the private benefits of light-rail transit (measured as the amount riders are willing to pay) approach the operating cost of such systems. Dallas has the lowest percentage at 13.3 percent, whereas Sacramento, Calif., has the highest at 62.3 percent. So, while some systems can cover more than half of their operating expenses with fare revenue, the private benefits to riders of rail transit in all cities are less than the cost of light-rail operation.

Is there a relationship between cost and service area size (as defined by the National Transit Database), as measured either by population, square miles or population density? This is an important question for cities thinking about starting or expanding light-rail service because it provides insights into the characteristics of cities that make light rail most cost-effective. To examine whether any relationship exists between service area characteristics and cost, a linear correlation was computed between each service area characteristic (size, density and population) and each of three cost measures (operating cost per passenger mile, operating cost per vehicle mile and fares as a percentage of the operating cost). Each correlation is shown in Table 4.

Table 3–Light-Rail Statistics for Selected U.S. Cities

City	Operating Cost (thousands $)	Fare Revenue (thousands $)	Operating Subsidy (thousands $)	Passenger Miles (thousands)	Vehicle Miles (thousands)
St. Louis	$34,025	$9,605	$24,420	126,728	5,156
Dallas	44,918	5,974	38,944	74,433	3,971
Denver	18,984	7,826	11,158	44,578	2,976
Sacramento, Calif.	24,129	15,043	9,086	46,711	2,128
Portland, Ore.	56,258	17,257	39,001	167,555	5,664
Philadelphia	41,425	14,331	17,094	54,575	3,027
Buffalo, N.Y.	14,735	3,155	11,580	14,157	838
Baltimore	32,027	6,205	25,822	56,647	2,634

	Operating Cost Per Passenger Mile ($)	Operating Cost Per Vehicle Mile ($)	Fare as % of Operating Expense	Service Area Population (thousands)	Service Area Size (square miles)	Service Area Density (pop./square miles)
St. Louis	$0.27	$6.60	28.2%	1,563	650	2,405
Dallas	0.60	11.31	13.3	2,200	689	3,193
Denver	0.43	6.38	41.2	2,400	2,406	998
Sacramento, Calif.	0.52	11.34	62.3	1,398	369	3,776
Portland, Ore.	0.34	9.93	30.7	1,254	574	2,184
Philadelphia	0.78	14.01	33.8	3,729	2,174	1,715
Buffalo, N.Y.	1.04	17.58	21.4	1,182	1,575	751
Baltimore	0.57	12.16	19.4	2,078	1,795	1,158

Note: Data are for 2002 and are from the Federal Transit Administration's National Transit Database. "Operating subsidy" is operating expense less fare revenue. "Vehicle miles" is the total of all mileage traveled by all vehicles in 2002. "Passenger miles" is the sum of all miles traveled by all passengers in 2002.

Table 4—Correlations between City Size and Light-Rail Costs

	Operating Costs per Passenger Mile	Operating Costs per Vehicle Mile	Fare as a % of Operating Expense
Density (pop./sq.mile)	-0.382	-0.233	0.381
Size (sq. miles)	0.177	0.031	-0.217
Population	0.389	0.148	-0.058

Note: Linear correlations are based on the eight cities listed in Table 3. Correlation can range from -1 to 1. A value of −1 reflects a perfect negative relationship, a value of 1 reflects a perfect positive relationship and a value of 0 reflects no linear relationship. Given the small sample size (n=8), none of the correlations is statistically significant at conventional levels.

The correlations in Table 4, albeit based on a small sample, provide some insight into the relationship between light rail's cost and service area characteristics. Larger service areas, as measured by either population or square miles, tend to have a larger operating cost per passenger mile and per vehicle mile, although the correlations are not very strong. In addition, there is a weak negative relationship between service area size (again, measured by either population or square miles) and fare revenue as a percentage of operating expenses. This suggests that larger service areas cover a smaller percentage of the operating cost with fares (or, larger service areas cover a higher percentage of the operating cost with subsidies).

The density correlations in the first row of Table 4 provide a different picture. Operating costs per passenger mile and per vehicle mile are lower in more densely populated areas. Light-rail systems in areas with greater population density are also able to cover a larger percentage of their operating cost with fares (or, the percentage of operating cost covered by subsidies is smaller).[9]

The simple correlations in Table 4 reveal that light rail's cost is positively related to population and service area size. That is, the larger the light-rail system, the larger the operating cost per passenger mile and per vehicle mile. Operating costs per passenger mile and per vehicle mile are lower in more densely populated areas.

III. Economic Issues Surrounding Light-Rail Transit

Whether light-rail systems in the United States benefit the communities that build them has been argued for many years. Proponents of light rail argue that rail transit increases community well-being by creating jobs, by boosting economic development and property values, and by reducing pollution and traffic congestion—all while providing drivers with an economical alternative to the automobile. Opponents counter that light-rail transit provides little of these benefits to citizens and that the cost of such systems greatly outweighs any potential benefits.

This section of the report discusses five key issues surrounding light-rail transit and is a starting point for debate. The issues are job creation, citizens' preferences for car over rail, air pollution, traffic congestion, and cost efficiency and solvency. Economic development is an important issue that will receive greater attention in Section IV of the report. Understanding these issues is important for residents in cities with existing light-rail transit and in cities considering proposals for building or expanding light rail.

Job Creation

Light-rail transit provides jobs during both construction and operation. Construction jobs are temporary and may go to contractors outside of the local area, depending upon the bidding process and job requirements. In Los Angeles, for example, transit cars came from Japan, Italy and Germany; other components—such as rails, power supplies, ticket vending machines and signaling equipment—were also produced outside of the southern California area.[10]

Although rail operation creates jobs in that industry, an important point is that these jobs are mostly taxpayer funded (given the large subsidies to rail transit). The salaries of rail transit workers paid for by subsidies should not count as new income to the local area—tax dollars have simply been transferred from local residents and state and national taxpayers to rail transit workers, effectively taking jobs from other industries. This is true of any public sector job. The income of rail-transit workers that is spent does help the local economy, but the same would be true for the dollars of citizens if they had not been taxed. In addition, although transit workers provide a benefit by operating light rail, the value of this benefit compared with the benefit citizens would receive from lower taxes is subjective.

If private development occurs around light-rail transit stations, giving people easier access to businesses, residential housing units and other facilities, then this private development will create jobs. Unlike rail transit jobs, these jobs would certainly provide a net benefit to the local economy.

Citizen Preferences: Rail vs. Car

It is not too surprising that most Americans prefer the automobile to light rail. Autos offer people personal space and a sense of independence. The fact that people choose to pay gas taxes, higher gas prices, the price of the car, repair and maintenance costs, and vehicle registration fees rather than ride rail transit all reveal the value that people place on their autos. The value people place on auto transit over rail transit is even more pronounced when one considers that rail transit fares can be less than a dollar or two per day.

Furthermore, rail transit is much more limited than automobile transit because trains must follow tracks and certain time schedules. This could certainly increase the time cost of rail transit relative to automobile transit. To take rail transit to work, for example, people may have to drive to a rail station, board the train and then, upon exiting the train, walk several blocks or more to reach work. The time taken to complete a rail ride may be longer than commuting by automobile. The opportunity cost of time, especially during work hours, makes it likely that many people will not ride rail transit.

Air Pollution

Proponents of light-rail transit say pollution will be reduced as a result of fewer vehicles on the roadways. A report from the American Public Transit Association presents evidence that each person riding light rail vs. driving an automobile for one year reduces hydrocarbon emissions by nine pounds, nitrogen oxide emissions by five pounds and carbon monoxide emissions by 62.5 pounds.[11] One electric light-rail train produces nearly 99 percent less carbon monoxide and hydrocarbon emissions per mile than one automobile does.

However, significant pollution reduction from light rail may not be realized. Large-scale gains in pollution reduction, assuming no growth in traffic congestion (discussed in the next section), can only be had if light-rail passengers substitute rail transit for auto transit. If many light-rail passengers do not own automobiles to begin with, then there is little reduction in pollution from the development of light rail.

Traffic Congestion

One idea behind adopting light-rail transit is that some automobile drivers will choose rail transit over their personal vehicles, thus alleviating traffic congestion, decreasing commute times and increasing highway safety. There is little evidence that rail transit has reduced traffic congestion. According to the *2002 Urban Mobility Report*, roadway congestion in American cities both with and without light-rail transit has steadily increased since the 1980s.[12] The 2002 report presents roadway congestion indices for 75 cities from 1982 to 2000.

Evidence suggests, however, that light rail may have slowed the growth in roadway congestion in some cities. Roadway congestion indices for four light-rail cities are shown in Table 5 along with annual percent changes in the index. The date light rail began operation in each city is marked in bold. The index is a relative measure, with an index value of 1.00 reflecting average roadway congestion. Values greater than 1.00 reflect above-average congestion, and values less than 1.00 signify below-average congestion. Although absolute levels of the congestion index in the four cities have increased since light rail was introduced, the cities have experienced a decrease in roadway congestion growth. Before light rail was introduced in Baltimore, the roadway congestion index increased an average of 2.8 percent a year. After light rail, however, the index increased an average of 1.5 percent a year. Average annual index growth in Sacramento before light rail was 4.5 percent and 2.2 percent after light rail. St. Louis and Dallas experienced less of a reduction in their roadway congestion index. For St. Louis, the average annual congestion index growth before and after light rail was 0.89 percent and 0.86 percent, respectively. The roadway congestion index growth in Dallas remained at an annual average of 2.3 percent before and after light rail was introduced.

Past research has also shown that rail transit ridership is greatest in more densely populated, lower-income areas.[13] As a result, light-rail proponents argue that rail will reduce rapid suburban growth by encouraging more concentrated development. However, the relationship among ridership and popula-

Table 5—Roadway Congestion Indices and Annual Percentage Changes

Year	St. Louis Index	St. Louis Annual % Change	Baltimore Index	Baltimore Annual % Change	Sacramento, Calif. Index	Sacramento, Calif. Annual % Change	Dallas Index	Dallas Annual % Change
1982	0.870	---	0.750	---	0.760	---	0.730	---
1983	0.875	0.57	0.775	3.33	0.796	4.77	0.759	3.94
1984	0.880	0.57	0.800	3.23	0.833	4.55	0.788	3.79
1985	0.885	0.57	0.825	3.12	0.869	4.35	0.816	3.65
1986	0.890	0.56	0.850	3.03	0.905	4.17	0.845	3.52
1987	0.895	0.56	0.875	2.94	**0.941**	4.01	0.874	3.40
1988	0.900	0.56	0.900	2.86	0.978	3.85	0.903	3.29
1989	0.905	0.56	0.925	2.78	1.014	3.71	0.931	3.19
1990	0.910	0.55	0.950	2.70	1.050	3.58	0.960	3.09
1991	0.930	2.20	0.963	1.32	1.068	1.67	0.960	0.00
1992	0.950	2.15	**0.975**	1.30	1.085	1.64	0.960	0.00
1993	**0.970**	2.11	0.988	1.28	1.103	1.61	0.960	0.00
1994	0.990	2.06	1.000	1.27	1.120	1.59	0.960	0.00
1995	0.998	0.81	1.014	1.40	1.136	1.43	0.982	2.29
1996	1.006	0.80	1.028	1.38	1.152	1.41	**1.004**	2.24
1997	1.014	0.80	1.042	1.36	1.168	1.39	1.026	2.19
1998	1.022	0.79	1.056	1.34	1.184	1.37	1.048	2.14
1999	1.030	0.78	1.070	1.33	1.200	1.35	1.070	2.10
2000	1.030	0.00	1.100	2.80	1.250	4.17	1.100	2.80

Notes: Data for 1982, 1990, 1994, 1999 and 2000 are directly from The 2002 Urban Mobility Report, *by David Schrank and Tim Lomax, Texas Transportation Institute, Texas A&M University, June 2002. The report is available at http://mobility.tamu.edu. All other years have been extrapolated on a linear basis. Bold type indicates the year the city began light-rail transit. An index value of 1.00 reflects average roadway congestion. Values greater than 1.00 reflect above-average congestion, and values less than 1.00 signify below-average congestion.*

tion density and income is not simultaneous—that is, density and income do influence ridership, but not vice versa. So, simply building light rail in higher-income suburban areas is no guarantee that rapid suburban growth will be reduced.

Traffic congestion exists because of inefficient pricing of roadway usage. To permanently reduce traffic congestion, a system must be in place that forces each driver to bear the full cost of his or her automobile usage. Consider the following explanation: A driver's use of a roadway imposes costs on the driver, such as fuel cost, time cost and depreciation of the automobile. The driver is not the only one to incur these costs—the costs are also transferred to all other drivers through increases in pollution and congestion (called externalities). The problem is that the driver does not pay for the costs that are imposed on other people. Because each driver does not bear the full cost (own costs + externalities), each driver overuses the roadway system. This follows a basic economic principle: If the cost of an activity decreases or is artificially low, then more of the activity will occur. Therefore, if each driver were forced to pay the full cost of driving, there would be a reduction in the number of cars on a specific roadway because the cost of operating a car on that roadway would increase.

Building new roadways or expanding existing roadways temporarily reduces congestion and pollution costs to all other people, but because these costs are now lower there is an incentive for more drivers to use the roadway. The roadway will eventually become as congested as it was prior to the expansion. Thus, building roadways to alleviate traffic congestion is only a short-run solution to the problem. A permanent solution to traffic congestion is to have each driver also bear the external cost of driving. One controversial method for doing this is toll roads, with the toll being equal to the cost each driver is imposing on other people.[14] Another possible solution is to set motor fuel tax rates at a level equal to an individual's total cost of driving. Because an increase in motor fuel taxes increases the cost of driving, some individuals may decide to use rail or bus transit instead of their automobile, thereby reducing pollution and congestion by some degree. There is a critical problem with using motor fuel taxes to reduce congestion, however. Because traffic congestion tends to vary during the day (e.g., rush hour), taxes may not be an effective way to alleviate congestion because motor fuel taxes are not directly linked with the level of congestion that changes throughout the day. The result is that nonrush-hour drivers will be overtaxed and rush-hour drivers will be undertaxed.

It is also important to realize that there is an optimal level of traffic congestion. A roadway with miles of bumper-to-bumper traffic is clearly an overused resource, but a roadway with no congestion at all is an underused resource. Thus, there exists some optimal level of congestion. By having some commuters in heavily congested areas substitute rail for car, it is possible that light rail serves as a marginal reducer of traffic congestion, thereby providing a more optimal amount of highway congestion.

Solvency and Costs

Light-rail transit, like other private and public transportation systems, cannot operate without subsidies from local sales taxes and state and federal grants. Subsidies to light-rail systems are not trivial. In 2001, MetroLink in St. Louis received at least

$14 million in local, state and federal assistance to cover operating costs. Sacramento received more than $18 million, and Portland received $24 million.[15] Fare revenue in these cities was $8.6 million, $7 million and $15.7 million, respectively. However, fares cover on average about 25 percent to 30 percent of operating expenses, with local, state and federal subsidies covering the remainder. Fares covered 38 percent of operating expenses in St. Louis, 28 percent in Sacramento and 39 percent in Portland in 2001.

Clearly, light-rail systems cannot cover their operating cost with passenger revenue. In St. Louis, for example, operating cost per rider in 2001 totaled $1.59 and revenue per rider totaled 60 cents. This shows the value that residents place on their transit system is much less than the system's operating cost. Fares would need to be nearly tripled for the transit system to cover its operating cost.[16]

However, raising fares would probably cause a reduction in the number of riders, which could result in lower overall fare revenue. One study of Philadelphia's rail system found that a 10 percent increase in fare revenue would reduce ridership by 6.2 percent over the short run.[17] Since the percent increase in fare is greater than the percentage reduction in ridership, total fare revenue would still increase (fare revenue = fare * number of riders). However, over the long run, the same study finds that a 10 percent increase in fare would reduce ridership by 15.9 percent, thus lowering total fare revenue. This long-run reduction in fare revenue would require increased subsidies to keep service constant or would result in decreased service and/or train quality and reliability.

Taxpayers are also responsible for the startup cost associated with rail transit. The capital expenditure needed to build or expand light-rail systems often totals hundreds of millions of dollars. The opportunity cost of this capital is high. The opportunity cost of light-rail capital is the foregone return to capital that could be obtained if the capital were allocated elsewhere. A lower-bound estimate of this cost is the return from investing rail capital in long-term Treasury securities. The opportunity cost of capital is the largest component of light-rail cost.

The failure to compute this cost understates the total economic cost of light-rail transit. Funding for light-rail capital is often obtained through city or county bond issues and state and federal grants. In addition to covering a majority of light rail's operating cost, taxpayers are responsible for funding bond payments and grants for light-rail construction.

If rail transit systems are cost-ineffective, why do voters approve local tax increases to fund operations? An extensive academic literature exists that explains citizen voting for public projects.[18] It is basically an issue of concentrated benefits and dispersed cost; people who would directly benefit from the construction and operation of light rail, such as laborers, bureaucrats, environmentalists and others form specialized interest groups that accrue political power and actively promote the benefits of rail transit to the public. The tax cost per taxpayer to cover operating costs is relatively small (in St. Louis, for example, it's about $6 per person annually for MetroLink), and the total cost of the project is spread across hundreds of thousands of voters. Thus, citizens approve rail transit taxes if special interest groups can convince voters that the social benefits of rail transit outweigh voters' individual annual tax cost. Although the tax cost per voter is small, in sum the total tax cost per year can be quite large, as seen in the previous section.

The aforementioned explanation can also be applied to the continued existence of cost-inefficient public projects. Because the tax cost per citizen is very low, each citizen would find that the cost of organizing and lobbying (e.g., time cost, lost wages)

Table 6–Cost Comparisons for Auto, Light Rail and Bus

	Auto	Light Rail	Bus
Cost efficiency per passenger mile			
Passenger miles	2,574,882,000,000	1,431,700,000	19,526,800,000
Operating cost	$124,815,000,000	$778,300,000	$12,585,700,000
Operating cost per passenger mile	$0.048 + $0.366 = **$0.414**	**$0.544**	**$0.645**
Cost efficiency per vehicle mile			
Vehicle miles	1,619,395,372,722	60,000,000	1,863,800,000
Operating cost	$124,815,000,000	$778,300,000	$12,585,700,000
Operating cost per vehicle mile	$0.077 + $0.582 = **$0.659**	**$12.972**	**$6.753**
Subsidy cost per passenger mile			
Passenger miles	2,574,882,000,000	1,431,700,000	19,526,800,000
Total subsidy	$24,938,036,000	$552,200,000	$9,127,400,000
Subsidy cost per passenger mile	**$0.010**	**$0.386**	**$0.467**
Subsidy cost per vehicle mile			
Vehicle miles	1,619,395,372,722	60,000,000	1,863,800,000
Total subsidy	$24,938,036,000	$552,200,000	$9,127,400,000
Subsidy cost per vehicle mile	**$0.015**	**$9.203**	**$4.897**

Note: All data are from the Federal Transit Administration's National Transit Database and the Federal Highway Administration's Highway Statistics. *Bus and light-rail data are from 2002, and auto data are from 2001. The total operating cost for an automobile is the tax cost for highways per passenger mile or per vehicle mile (passenger miles or vehicle miles divided by operating cost) of $0.048 or $0.077, plus the personal per passenger mile or per vehicle mile cost of operating an automobile ($0.366 and $0.582, respectively). These data are from the American Automobile Association,* Your Driving Costs, *2001 Edition, Heathrow, Fla. Available at www-cta.ornl.gov/data/tedb22/Spreadsheets/Table5_12.xls. Subsidy for light rail and bus service is the difference between operating cost and fare revenue. Subsidy for auto usage is total highway disbursement by all levels of government less total highway tax revenues.*

to remove or reduce a public project outweighs his or her annual tax cost. Thus, because the expense of a public project is spread across numerous taxpayers and the cost per taxpayer is very small, it is expected that few citizens would find it beneficial to take action against any public project once it is in place.

How does the operating cost of light rail compare with other forms of transportation, such as bus service and private automobiles? An accurate evaluation of any transit system must involve a comparison with alternatives.[19] Operating and subsidy costs on both a per passenger mile and on a per vehicle mile basis for light-rail transit, bus service and the private automobile are shown in Table 6.

The cost of automobile usage consists of two parts. First, the total highway expenditures for all levels of governments (local + state + federal) are the total tax cost of automobile usage. This amount is then expressed in terms of vehicle miles or passenger miles. Second, the American Automobile Association (AAA) annually computes the average operating cost (fuel, insurance, tires, oil, depreciation, license fees and maintenance) per vehicle mile and per passenger mile.[20] The sum of this cost plus tax cost per mile is the total operating cost per vehicle mile or per passenger mile for the private automobile. These two costs are shown separately in Table 6.

The subsidy for autos is different than that for bus service or light rail. For autos, the subsidy is the difference between total highway expenditures at all levels of government less total highway tax revenues, such as gas taxes and registration fees. Subsidies for bus service and light rail are computed as the difference between operating cost and fare revenue.

The data in Table 6 allow an interesting comparison of operating and subsidy cost for the three studied modes of transportation. The private auto has the lowest operating cost per passenger mile and per vehicle mile. Of these two costs, per passenger mile is the most relevant comparison because motor vehicles and light-rail trains are very different vehicles, and the per vehicle measure does not account for the large difference in passenger capacity of each vehicle.[21]

The automobile also has the lowest subsidy cost per passenger mile and per vehicle mile. In fact, the difference between autos and the other forms of transportation is quite large. On a per-passenger-mile basis, subsidies for the automobile are about 1 cent, whereas the subsidy for light rail and bus transportation is 39 cents and 47 cents, respectively.

Subsidies for auto transit are more efficient than subsidies for light rail because there is a more direct link between benefits received and costs paid. In fact, most of the money going for auto transit is not a true subsidy by definition because the vast majority of people who pay gas taxes and other fees also use the nation's highways. Thus, rather than each citizen directly paying his or her cost of highway usage each time, the government simply collects taxes from the citizenry to pay for highway costs. Government money to light rail, however, is more of a true subsidy because only a small portion of the citizenry uses light rail but the vast majority pays for it.

Quantifying the true cost of transportation alternatives is difficult because there are numerous factors that must be considered in the cost calculation. These include external costs and depreciation costs. Because it is hard to get an accurate measure of these costs, it is difficult to provide an accurate cost comparison of various forms of transit. Proponents and opponents can take advantage of this difficulty to present data that favor their position regarding light rail and other forms of transit. Regardless, the data in Table 6 and the earlier discussion attempt to sort out these costs as best as possible to reveal the operating and subsidy cost per passenger mile and per vehicle mile for automobile, light rail and bus transit.

Transportation for the Poor

Despite its relative cost-inefficiency, light rail provides transportation to thousands of low-income individuals who otherwise would find their mobility quite limited. However, the data in Table 7 put into perspective the dollar cost of helping the poor via light-rail transit, using MetroLink in St. Louis as the basis for demonstration. The analysis makes the assumption that all MetroLink riders without cars are considered poor (about 14 percent of all riders). Although there are certainly some riders without cars who would not be considered poor and others with cars who would be considered poor, there is no absolute measure available for a "poor MetroLink rider." Given that there is a high correlation between income and car ownership, defining riders without cars as poor is a reasonable assumption.[22] In addition, even though there may not be a direct link between not having a car and poverty, defining 14 percent of all MetroLink riders as poor likely is a reasonable approximation to the actual percentage of all MetroLink riders who are poor.[23]

Table 7–Cost Comparison: Light Rail Subsidies for Poor vs. New Cars for Poor

(1) Annual total subsidy to St Louis' MetroLink[a]	$133,043,678	
(2) Number of poor MetroLink riders (riders without cars)[b]	7,700	
(3) Twelve monthly payments for hybrid Toyota Prius costing $20,000 assuming 8% interest, $0 down, for 60 months[c]	$4,866.36	
(4) Annual cost of operating a car[d]	$6,000	
(5) Total payment to poor riders	$83,670,972	((3)+(4))*7,700
(6) Funds remaining after car payment	$49,372,706	(1)-(5)
(7) Annual per-rider transfer possible to all other MetroLink riders	$1,043.82	(6)/47,300

[a] *This figure is equal to the total (operating + capital) subsidy to MetroLink in 2001 from local, state and federal sources ($105,203,678) plus the opportunity cost of the $348 million federal grant to pay for MetroLink construction. Assuming an 8 percent annual rate of interest, the annual opportunity cost amounts to $27.84 million. Subsidy data are from the National Transit Database, 2002, and federal grant information is from www.metrostlouis.org/InsideMetro/insideMetroLink.asp.*

[b] *Computed using data from "A New Way to Grow," page 2 – www.cmt-stl.org. Poor riders are defined here as those without an automobile. Daily ridership on MetroLink is roughly 55,000. It is assumed here that the same individuals ride MetroLink each weekday. About 86 percent of MetroLink riders have at least one car. So, 55,000 * (1-0.86) = 7,700 riders without a car.*

[c] *www.automotive.com/toyota/11/prius.*

[d] *Data are estimated from American Automobile Association, 2001. For a hybrid vehicle, the $6,000 in annual operating cost is likely an overestimate.*

Based solely on dollar cost, the annual light-rail subsidies that are expended each year could instead be used to purchase an environmentally friendly hybrid Toyota Prius (priced at $20,000) every five years for each poor rider, including an annual maintenance cost of $6,000. Increases in pollution would be next to zero with the hybrid vehicle, and 7,700 new vehicles on the roadway would result in only a 0.5 percent increase in traffic congestion in the St. Louis metro area.[24] And there would still be funds left over—about $49 million per year. This money could be given to all nonpoor MetroLink riders (amounting to roughly $1,045 a year) to be used for parking, cab fare, bus fare and other transportation expenses.

Thus, there is no difference between current MetroLink financing and the alternative of buying each poor rider a new hybrid vehicle (and paying maintenance costs) every five years in addition to giving all other MetroLink riders more than $1,000 a year that could be spent on other transportation alternatives.

An analysis similar to the one above was conducted by an economic development and public transit think tank.[25] Instead of using operating cost like the analysis above, the study focused on light-rail construction cost. Its analysis compared the annual construction cost per commuter for several light-rail systems across the country with the annual cost of purchasing or leasing a new car. The authors found that all light-rail-project costs per rider are more expensive than buying each rider a Ford Taurus or Plymouth Voyager minivan, which was still being made when the study was done. And the most costly projects per rider were more expensive than buying each rider a Cadillac SLS, BMW 740 or a Lincoln Town Car.

The above examples are extreme alternatives, and neither the author nor his employer is advocating that any level of government purchase new cars for the poor. The point of this exercise is to make obvious the cost of providing light rail by simply showing that on a dollar basis there is no difference between the cost of providing light-rail transportation or providing each poor rider with the money required to buy a new car. The difference between these two possibilities is purely subjective and depends upon societal preferences.

The aforementioned MetroLink example assumes that new cars are bought for poor riders and the remaining money is given to all other MetroLink riders. If the total subsidy (row 1, Table 7) were given to all MetroLink riders, then each rider would receive about $2,372 a year (row 1, Table 7 divided by 55,000). This money could be used to pay for bus fare, cab fare or other forms of transportation. Although bus service is also cost-inefficient, it is socially beneficial to have fewer inefficient public transportation systems.

The overall cost of light rail, and the cost of providing rail transit to the poor, can certainly be justified if society obtains some intangible benefit (e.g., pride, generosity, compassion) from knowing that light rail exists in the community. This is similar to the community pride argument made in favor of using tax dollars to finance the construction of professional sport stadiums. Measuring these intangible benefits that society may receive, however, is difficult. So, although providing light-rail transportation is very costly, each community must weigh the cost with the tangible and intangible benefits it receives from light rail. If these benefits are high enough, then the dollar cost can certainly be justified.

IV. Light Rail: Economic Development and Property Values

The most important economic question surrounding light rail is whether it can help foster economic development. As discussed earlier, many of the heavy-rail systems in the United States were developed out of necessity because of massive congestion in America's largest cities. However, in the 1960s and 1970s, the introduction of light rail was seen as not only a way of reducing pollution and congestion in midsized cities, but also as a means of promoting economic growth.

This section of the report focuses on two aspects of economic development and light rail. The first is whether light-rail systems have a positive or negative effect on residential and commercial property values. The economic theory behind these potential effects will be discussed. The second aspect of light rail is transit-oriented development (TOD). TOD involves collaboration among city officials, private developers and the business community in an effort to spur development around light-rail stations.

Does Light Rail Affect Property Values?

Early research on light rail and other public transportation systems suggested that property values were influenced by accessibility, defined as the straight-line distance from the property to the central business district.[26] Basically, any improvement in an area's transportation structure that increases accessibility and reduces transportation cost should be capitalized into property values. Property value improvements to existing homes and businesses simply come from greater accessibility afforded by rail transit, not necessarily by any new construction that stems from the existence of light rail (which will be discussed later). Based on this theoretical construct then, the typical spoke-like design of light-rail tracks to and from the city center and the strategic placement of stations in residential and commercial areas should have a positive impact on property values.

Although the argument for a link between accessibility and property values seems logical, empirical research on the issue suggests a more ambiguous relationship. A summary of several empirical studies on light rail and property values is shown in Table 8. This list is not exhaustive, and a careful reading of these studies will provide references for further work on the issue. Nevertheless, the mixed conclusions of the studies are representative of the literature.

The studies listed in Table 8 reveal that the impact of light rail on property values cannot be generalized. Some areas have seen a positive effect on property values, but for those areas the effect has been modest. Although the dollar amounts may be

Table 8—Rail Transit and Property Values: A Summary of Studies

Study	Location	Findings
Bajic (1983)	Toronto	Commuting cost savings of $2,200 for the average household are fully capitalized in housing values.
Armstrong (1994)	Boston	Houses located in communities with rail service have a market value about 6.7 percent higher than residences in other communities. But property values are 20 percent lower for homes within 400 feet of track/station.
Baum-Snow and Kahn (2001)	Boston; Atlanta; Chicago; Portland, Ore; Washington, D.C.	A decrease in transit distance from three kilometers to one kilometer would increase rents by $19 per month and housing values by $4,972.
Gatzlaff and Smith (1993)	Miami	Announcement of light rail had weak effect on housing property values. This impact did not vary by distance from station. Fixed-rail investment did not lead to neighborhood revitalization.
Weinberger (2001)	Santa Clara, Calif.	Commercial properties that lie within 0.5 miles of a light-rail station command higher lease rates.
Chen, Rufolo and Dueker (1998)	Portland, Ore.	Light rail has both a positive (accessibility) effect and negative (nuisance) effect on housing values. Positive effect dominates, but net result is small. At 100 meters, every meter farther away lowers the price of the average house by $32.30.
Damm et al. (1980)	Washington, D.C.	Small, positive effect on single-family, commercial and multifamily properties. However, results cannot be differentiated among other development policies.
Bowes and Ihlanfeldt (2001)	Atlanta	Properties within a quarter mile of the station sell for 19 percent less than homes beyond three miles. Properties between one and three miles have a higher value compared with those more than three miles away.

* *Armstrong, Robert J. Jr. "Impacts of Commuter Rail Service as Reflected in Single-Family Residential Property Values."* Transportation Research Record, *Vol. 1466, 1994: pp. 88-98.*
* *Bajic, Vladamir. "The Effects of a New Subway Line on Housing Prices in Metropolitan Toronto."* Urban Studies, *Vol. 20, 1983: pp. 147-58.*
* *Baum-Snow, Nathaniel and Kahn, Matthew E.. "The Effects of New Public Transit Projects to Expand Urban Rail Transit."* Journal of Public Economics, *Vol. 77, 2001: pp. 241-63.*
* *Bowes, David R. and Ihlanfeldt, Keith R.. "Identifying the Impacts of Rail Transit Stations on Residential Property Values."* Journal of Urban Economics, *Vol. 50, 2001: pp. 1-25.*
* *Chen, Hong; Rufolo, Anthony; and Dueker, Kenneth J. "Measuring the Impact of Light Rail Systems on Single-Family Home Values: A Hedonic Approach with Geographic Information System Application."* Transportation Research Record, *Vol. 1617, 1998: pp. 38-43.*
* *Damm, David; Lerman, Steven R.; Lerner-Lam, Eva; and Young, Jeffrey. "Response of Urban Real Estate Values in Anticipation of the Washington Metro."* Journal of Transport Economics and Policy, *Vol. 14, No. 3, September 1980: pp. 315-36.*
* *Gatzlaff, Dean H. and Smith, Marc T. "The Impact of the Miami Metrorail on the Value of Residence Near Station Locations."* Land Economics, *Vol. 69, No. 1, February 1993: pp. 64-66.*
* *Weinberger, Rachel. "Light Rail Proximity: Benefit or Detriment in the Case of Santa Clara County, California."* Transportation Research Record, *Vol. 1747, 2001: pp. 104-13.*

small (for example, a $4,900 increase on average, or a $32.20 decrease for every meter away from the station), in percentage terms the effect may be quite large given that the average house price in many of these studies is about $100,000. Other studies suggest that accessibility and distance to a light-rail station may not matter, but rather just the presence of light rail in the community has a positive impact on property values.

The finding of negative effects on property values goes contrary to the accessibility theory. Studies have reconciled this finding with the presence of nuisance effects from light rail, such as noise and unsightly tracks. The nuisance and accessibility effects have opposing influences on property values. An overall negative influence on property values suggests the nuisance effect dominates, whereas an overall positive influence reveals that the accessibility effect dominates.[27]

The studies shown in Table 8 and other research discuss several alternative reasons for the weak and inconsistent relationship between light rail and property values.[28] First, light rail may not impact accessibility because of a fixed route, a limited number of stations and a relatively small percentage of total travelers (compared with auto) in a given area. Similarly, highway systems in most American cities provide easier access to more locations and have been well-developed prior to light rail. Thus, the marginal contribution of light rail to overall accessibility, compared with highway systems, is quite low.

Measurement technique and sample periods studied are two other issues. There are numerous factors affecting property values, including local public policies, neighborhood and housing characteristics, and changes in economic conditions. All of these factors must be controlled for in order to distinguish any marginal increase in property values resulting from light rail. In addition, many empirical studies examine the influence of light rail on property values using data on years immediately following the introduction of light rail. Distinguishing between property value changes caused by light rail and changes caused by other factors is more difficult with a sample covering a limited time period. In addition, it is possible that there are time lags in the capitalization of light rail into property values. Given that most studies only use data on a few years after the start of light rail, it is possible that the full impact of light rail on property values, if there is one, is not captured in these empirical models. In fact, one study explored the impact of San Francisco's Bay Area Rapid Transit (BART) system by using data for 1990, nearly 20 years after BART began operations.[29] The study found that the price premium associated with proximity to a station was about $2.30 per meter (average home price was $234,000). This contrasted with BART studies conducted in the late 1970s, only several years after BART began operating, that found a price reduction or no price premium as a result of BART.[30] Although BART is considered a heavy-rail transit system, perhaps a re-estimation of recent light-rail studies in a decade or so would provide different and more definitive results regarding the impact of light rail on property values.

Despite wide variation in the estimates of light rail's impact on property values, can there be any consensus regarding light rail's influence on property values? One study analyzed numerous light-rail studies in order to provide policy-makers and local officials some general information regarding the relationship between light rail and property values.[31] The study suggests that rail transit in relatively dense areas that significantly improves accessibility to city centers (such as Washington, D.C., and New York City) will result in higher property values the closer a home or business is to a light-rail station. This result may be less clear in less densely populated cities or in those cities without a vibrant city core. According to the author of the study, "urban rail transit will significantly benefit land use and site rents only if a region's economy is growing and a number of supportive programs are in place, for example, permissive zoning to allow higher densities, and infrastructure such as pedestrian plazas and street improvement. Transit guides rather than creates growth, and by itself rarely affects significant land use changes."

Table 9—Transit-Oriented Development Projects, Selected Web Sites

City	Transit Agency Web Site With a Description of TOD Projects
Dallas	www.unt.edu/cedr/dart2002.pdf
Sacramento, Calif.	www.cityofsacramento.org/econdev/city/2214_transit.html
Portland, Ore.	www.todadvocate.com/pdxcasestudy.htm
Denver	www.rtd-denver.com/Projects/TOD/index.html
St. Louis	www.metrostlouis.org
Salt Lake City	www.rideuta.com
Buffalo, N.Y.	www.nfta.com

Transit-Oriented Development (TOD)

Transit-oriented development (TOD) involves the collaboration of city officials, developers and business leaders in an effort to foster economic development using the community's transit system. Formally, TOD is defined as "any formal, legally binding arrangement between a public entity and a private individual or organization that involves either private-sector payments to the public entity or private-sector sharing of capital or operating costs, in mutual recognition of the enhanced real estate development potential or higher land values created by the siting of a public transit facility."[32]

TOD involves public-sector and private-sector parties sharing costs, resources and information to facilitate economic development near light-rail stations. Private- and public-sector cost-sharing for excavation, construction, labor, parking lots, heating and cooling, and other expenses are common. In addition, local governments can modify zoning laws to give developers greater incentives to construct new building around light-rail stations. Developers may be enticed to contribute a portion of the light-rail system's capital startup cost in return for a share of future fare revenue or for a tax reduction on properties constructed near light-rail stations. Other projects have involved the joint leasing of station space and cost-sharing station rehabilitation. Table 9 provides a directory of several web sites that have descriptions of specific TOD projects or other information on the use of light rail to promote economic development.

Development around light-rail stations can occur without the formal cooperation of the public and private sectors. If private developers see an opportunity for profitable residential or commercial property around rail stations, then public officials should ensure that there are few barriers in place to prevent such development. Although the public and private sectors are not sharing resources in this case, the public sector is facilitating economic development by reducing regulation and tax costs to developers.

TOD can positively influence residential and commercial property values. The growth in productive commercial property around transit stations raises property values for existing properties. Depending on the location of residential properties relative to the commercial properties, homeowners may also see an increase in property values. This fact and the earlier discussion on property values suggests there are two possible ways for light rail to influence property values: (1) through the accessibility effect—homes and businesses being closer to a rail station that provides greater access to city centers, and (2) through TOD and the creation of more productive and valuable properties around rail transit stations. One study of the Washington, D.C., and Atlanta metro areas found significant increases in office rents and office densities and lower office vacancy rates as a result of TOD.[33]

Has TOD been a success at fostering economic growth around light-rail stations? There has been very little research on this question, but one study suggests that TOD has brought only modest benefits to transit agencies.[34] Although the study only examines TOD through the mid 1990s, the author finds that private capital contributions to TOD projects in New York amounted to about 4 percent of transit agencies' total capital outlays. Similarly, capital contributions to transit agencies' TOD projects in Washington, D.C., and Atlanta accounted for 0.7 percent and 0.2 percent of total rail expenditures, respectively. There are two possible explanations for the modest benefits transit agencies receive from TOD. First, transit agencies may have limited experience in appraising property values and in negotiating real estate transactions with private developers. Second, transit boards may be hesitant to participate in real estate purchases and other business ventures.

TOD has the potential to create economic development around light-rail stations. This development is often promoted as one of the major benefits of light rail. However, several points need to be addressed regarding TOD and light rail. First, only with active cooperation among city officials, developers and transit agencies can the full potential of TOD be realized. Zoning laws and unnecessary regulations on development must be changed to allow unfettered development around light-rail stations. No matter how well developers, city officials and transit agencies cooperate, unnecessary cost and regulations will impede economic development.

It is also important to realize that any economic development coming directly from light rail is subsidized economic development. Recall in the previous section of this report that nearly 70 percent of light-rail operating costs are covered by subsidies, paid for by a transfer of tax dollars from the citizenry to transit agencies. In evaluating the total economic development benefits of light rail, the tax cost to the citizenry must be subtracted from the total value of any development that may occur. The development doesn't occur for free; millions of tax dollars are used to cover the capital and operating cost of light rail.

Before embarking on TOD as a means for promoting economic development, city officials should address a fundamental question: Why is little or no economic development occurring in a given area? Crime, tax rates, regulations and demographics are all factors that businesses consider when deciding where to locate. Unless there is a favorable business climate in a given area, it is unlikely that businesses will choose to locate to that area on their own.

Although light rail may help attract businesses, the total societal benefit from these businesses is less than if subsidized light rail was not used as a tool to promote growth. Community leaders who fail to address the fundamental question of why economic development is slow to occur without tax dollars and help from city government will hinder potential economic development. For a city's economy to grow, officials must correct the root problems responsible for a lack of economic development. As mentioned earlier, light rail can help guide growth, but it rarely leads to sustainable growth. Other viable alternatives for sustainable economic development are to lower taxes on individuals and businesses and to eliminate unnecessary regulations and zoning laws. All of these measures reduce the cost of doing business by putting more money into the hands of residents and business owners. It is this income, unlike the subsidy to light-rail tax, that will generate positive societal wealth and that will further economic development.

V. Light Rail and Property Values: A Study of the St. Louis MetroLink

This section presents an analysis of the effect of St. Louis' light-rail system, MetroLink, on residential property values in St. Louis County. As in past studies of light rail and property values, the basic premise here is that homes closer to light-rail stations will have higher property values, holding all other factors (house, neighborhood and economic characteristics) constant. That is, light rail raises property values because accessibility to the city center has increased.

However, as discussed in Section IV, studies of other light-rail systems have suggested an ambiguous relationship between light rail and residential property values. Several factors explained the lack of a clear relationship between light rail and property values. These factors included:

- There may be a measurement error in empirical modeling.
- Light rail may not impact accessibility because of a fixed route, a limited number of stations and a relatively small percentage of total travelers (compared with auto) in a given area.
- Highway systems in most American cities provide easier access to more locations and have been well-developed prior to light rail.
- Light rail isn't available in growing suburban areas, but rather only in low- or no-growth downtown areas. The general consensus from the academic literature is that rail transit in relatively densely populated areas will result in higher residential property values, but this result may be less clear in less densely populated cities or in those cities without a vibrant city core.

As a result of these confounding influences, the effect of MetroLink on property values remains to be seen. A brief historical background and summary statistics on MetroLink are provided in the next section. A discussion of the methodology and study area follows, along with the empirical findings. These findings are then discussed and compared with the results of studies of light rail and property values in other cities.

MetroLink: History and Statistics

The Metro transit agency owns and operates the St. Louis metropolitan area's mass transportation system that includes bus (MetroBus) and light-rail (MetroLink) service. Construction began on the initial phase of MetroLink line in 1990 and was completed in July 1993.[35] The initial line had 18 stations and ran 17 miles, from East St. Louis in Illinois westward across the Mississippi River into downtown St. Louis, continuing westward into St. Louis County and ending at Lambert-St. Louis International Airport. The capital cost to build the initial line was $464 million. Of this total, $348 million was provided by the Federal Transit Administration and $116 million was obtained from sales tax increases and local bond issues.

MetroLink has expanded since its inception in 1993. In 1994 and 1998, new stations were built at Lambert Airport. In May 2001, a 17.5-mile stretch opened in St. Clair County, Ill.,

Figure 1–MetroLink in St. Louis

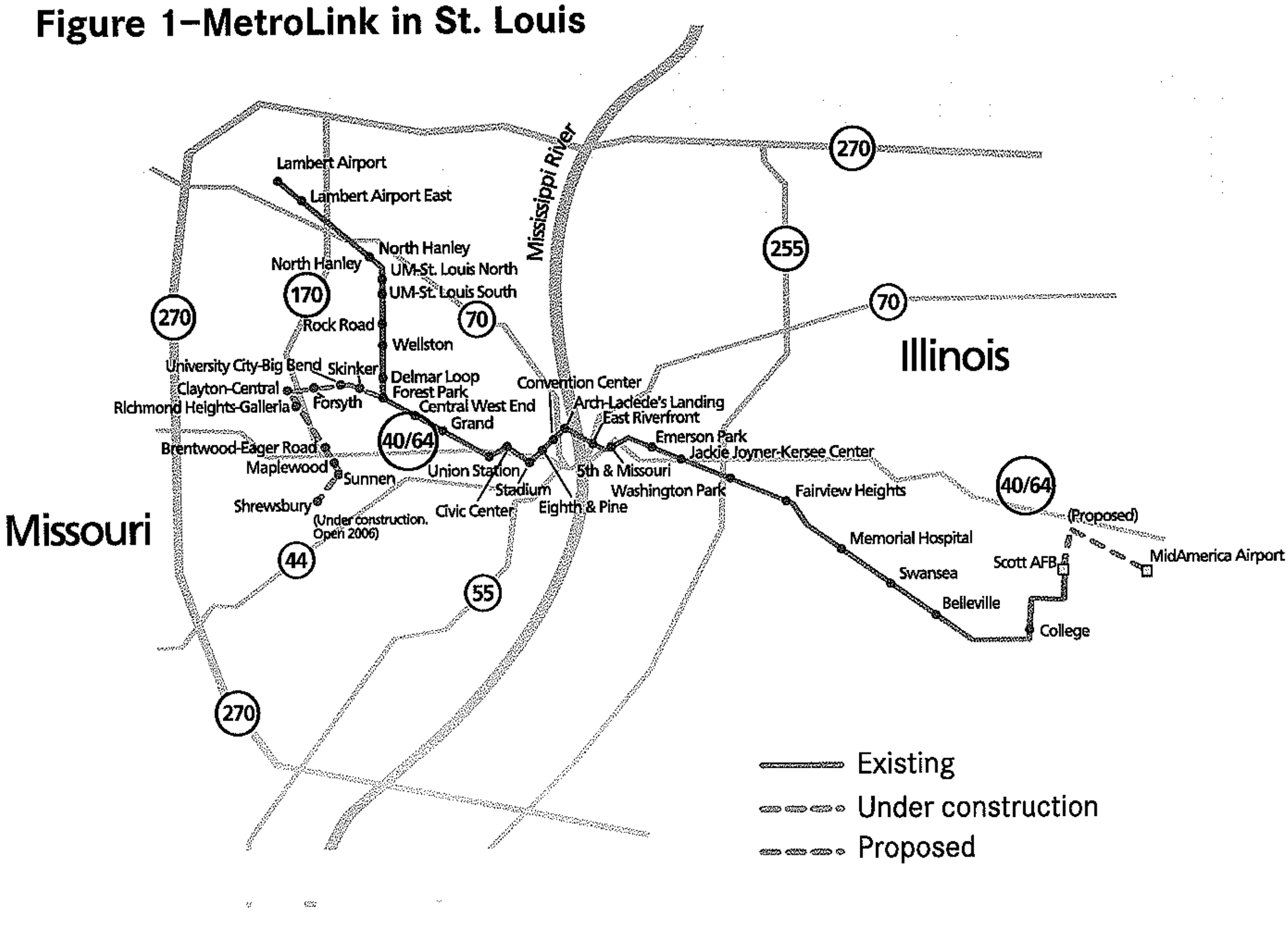


Table 10–Light-Rail Rider and Route Statistics

	St. Louis	Dallas	Sacramento, Calif.
Miles of track	38	44	21
Number of stations	28	34	31
Average weekday ridership	55,000	59,000	29,500

running from East St. Louis eastward to Southwestern Illinois College in Belleville. An additional 3.5 miles was added in June 2003, continuing eastward from Belleville to Shiloh-Scott, Ill. MetroLink currently has 38 miles of track and 28 stations, of which 16 have park-and-ride lots.[36] Annual ridership is nearly 15 million, with an average weekday ridership of 45,000 to 55,000. Route and rider statistics for MetroLink and several other light-rail systems are shown in Table 10.

Future MetroLink expansions include an extension eastward in Illinois from Shiloh-Scott to the MidAmerica Airport and an eight-mile cross-county extension running north-south through eastern St. Louis County. The cross-county extension is currently in progress and has a 2006 completion date. A map of the MetroLink line that includes current and future expansions is shown in Figure 1.

Financing for MetroLink comes from a variety of sources. In January 1995, St. Clair County in Illinois adopted a half-cent countywide sales tax that can only be used for capital projects and operating expenses related to MetroLink in Illinois. The city of St. Louis and St. Louis County receive revenue from half-cent and quarter-cent local sales taxes approved by voters in August 1994 as Proposition M. The city allocates all revenue from its quarter-cent and half-cent sales taxes to Metro. The county appropriates roughly $40 million per year to Metro from its sales taxes and uses the remaining balance to fund road and bridge repairs.

In addition to taxes, capital projects are funded by local bond issues (which are paid off using future tax dollars) and by grants from state and federal agencies. In 2002, federal funds covered 45 percent and 10 percent of capital and operating expenses for Metro, respectively; state funds covered 24 percent and 3 percent of capital and operating expenses, respectively; and local funds (sales tax revenues) covered 31 percent and 65 percent of capital and operating expenses, respectively.[37] Fare revenue covered the remaining 22 percent of the operating cost.

MetroLink and Residential Property Values in St. Louis County

Previous research on light rail and residential property values suggests that light rail can have two opposing influences on property values: a positive accessibility effect and a negative nuisance effect. The accessibility effect mentioned earlier is based on the idea that any improvement in an area's transportation structure (e.g., building light rail) that increases accessibility should be capitalized into property values. On the other hand, increased noise, lighting and other nuisances from light rail may have a negative influence on property values the closer a home is to light-rail tracks. The analysis here considers both effects of MetroLink on property values in St. Louis County.

The methodology used here, based on past academic research, involves first developing a model that includes all potential variables that may affect single-family house prices, such as neighborhood characteristics and house characteristics. Once these characteristics are controlled for, variables that measure the distance of each home from the nearest MetroLink station and MetroLink track are included to separately capture the accessibility effect and the nuisance effect, respectively. A more detailed description of the empirical model used in the

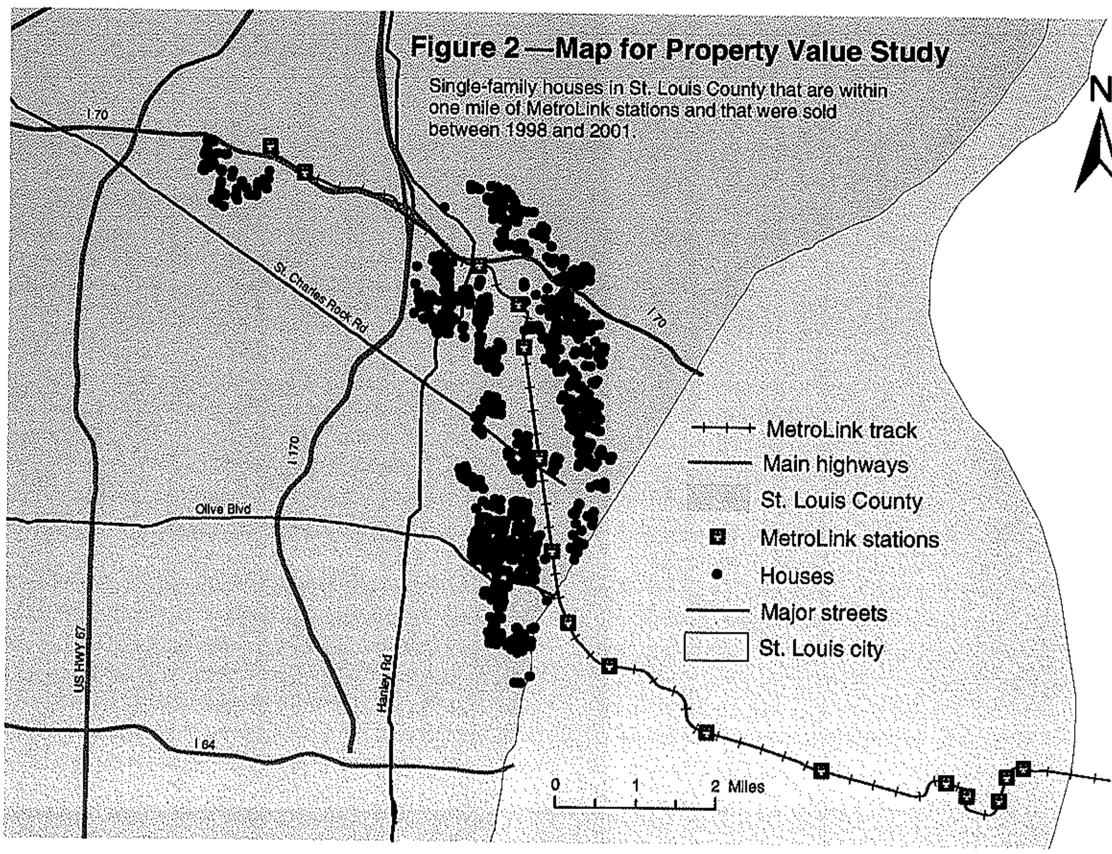


Figure 2—Map for Property Value Study

Single-family houses in St. Louis County that are within one mile of MetroLink stations and that were sold between 1998 and 2001.

analysis can be found in the appendix.

If proximity to light-rail stations does increase accessibility, then property values should increase the closer homes are to a light-rail station—that is, there is an inverse relationship between property values and distance from a light-rail station. However, if proximity to light-rail tracks introduces nuisances, then property values should decrease the closer homes are to the light-rail tracks, thus suggesting a positive relationship between property values and distance to light-rail tracks.

The analysis here uses data on single-family homes in St. Louis County that were sold over the period 1998 to 2001 and are located within one mile of a MetroLink station.[38] Previous work has shown that the effect of light rail on property values is strongest up to 700 meters (approximately 2,300 feet) from a light-rail station.[39] The analysis here thus looks at two different sets of homes—those located up to 2,300 feet from a station and track and those homes located 2,300 feet to 5,280 feet (one mile) from a station and track. In all, 1,516 homes are used in the analysis.[40] A map of the study area is shown in Figure 2. All data on house characteristics (number of bedrooms, garage, age, pool, etc.) and home prices were obtained from First American Real Estate Solutions. Neighborhood characteristics were obtained from the U.S. Census. All variables used in the analysis are presented in Table 11.

Eight different models were estimated. The reliability of the estimates increases with model number, as does model complexity. The conclusions from the models are shown in Table 12, and a graphical representation of the estimated nuisance and accessibility effects described in Table 12 is shown in Figure 3.

In all eight models, the distance to track does not affect prices for properties located within 2,300 feet of a MetroLink track. Only two models predict that distance from a MetroLink track has a significant effect on house prices beyond 2,300 feet. Specifically, over 2,300 feet to 2,800 feet from the track, home prices increase slightly with distance—an average of $12.14 for every 10 feet farther from the track. What this means is that a home located 2,800 feet from the track will have a price premium of $607 ($12.14 * [2,800 – 2,300]/10) compared with a home located only 2,300 feet from the track. With an average home price of $86,856 over this distance range, this premium amounts to a 0.7 percent increase in home value (computed as ([$86,856 + $607]/$86,856 – 1)).

Beyond 2,800 feet, however, home prices decrease at a much greater rate—an average of $54.38 for every 10 feet farther from the track up to 5,280 feet (one mile). This can be seen in Figure 3. Thus, although there is a small increase in property values for homes located within 2,300 to 2,800 feet of a track, as distance from the track rises, the property values of homes beyond 2,800 feet show a much larger decrease in property values. On average, a home located one mile from the track will be valued 15.5 percent lower than if it was located only 2,800 feet from the track. The relatively large decrease in property values beyond 2,800 feet compared with the small gain in value for homes located over 2,300 to 2,800 feet suggests that, for the entire sample of homes, property values decrease with distance from a MetroLink track.

The majority of models, however, reveal that distance to track has no effect on home prices, and only two models reveal that home prices decrease with distance. Thus, one can conclude there is no overall nuisance effect associated with MetroLink and that there is only mild evidence that distance from a MetroLink track has any impact whatsoever on home values.

There is evidence, however, that distance from a MetroLink station has a significant influence on property values. An accessibility effect is found for those homes within 1,460 feet of a MetroLink station (Figure 3). On average, home values increase $139.92 for every 10 feet closer they are to a MetroLink station, beginning at 1,460 feet. Thus, a home located 100 feet from a station will have a price premium of $19,029 ($139.92 * [1,460 –100]/10) compared with a home that was located 1,460 feet from the same station. Given that the average home price over this distance is $63,564, this translates into a 31.25 percent to 32.72 percent increase in property value when averaging across the four models.

Although this percentage increase in property values may seem large, it is important to realize that the homes in this area have relatively low property values. Thus, even a moderate premium for being located near a station can be a significant percentage of the overall home value. Although keeping this in mind, there is still strong evidence that homes located near MetroLink stations experience a premium because of an accessibility effect.

Beyond 1,480 feet, however, home prices rise with distance to station. On average, for homes located over 1,490 feet to 2,300 feet from a MetroLink station, property values increase $69.50 for every 10 feet farther they are from the station. However, the increase from being farther from the station is less than the increase from being closer to the station. This suggests that for the entire sample, a house will show a premium the closer it is to a MetroLink station.

What are some factors to keep in mind when interpreting these results? First, complete capitalization of accessibility into house prices may have not yet occurred—there is a considerable time lag for accessibility to be capitalized into home prices. Thus, an analysis conducted five or 10 years from now that is

Table 11—Variables Used in MetroLink Property Value Study

House Characteristics	Neighborhood Characteristics
Price	Distance to nearest highway interchange
Number of bedrooms	Percent of residents with a college education
Number of bathrooms	Per capita personal income
Number of stories	Property tax rates
Garage (yes/no)	School district test scores
Pool (yes/no)	Nearest light-rail station has a park-and-ride (yes/no)
Age	
Lot size (sq. ft.)	
Living area (sq. ft.)	
Variable to Measure Nuisance Effect*	**Variable to Measure Accessibility Effect***
House distance to nearest MetroLink track (ft.)	House distance to nearest MetroLink station (ft.)

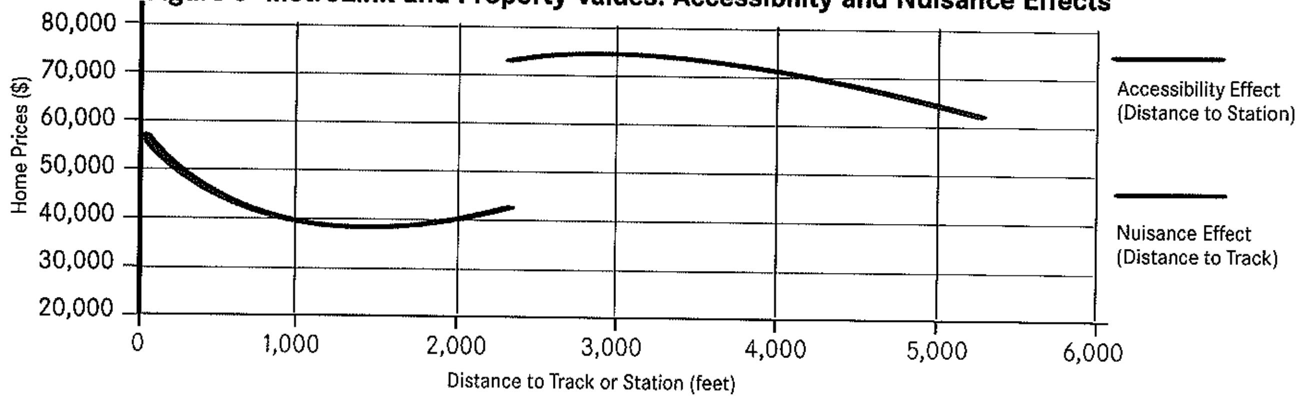
**Both the accessibility effect and the nuisance effect are estimated separately on homes that are 0 to 2,300 feet (≈ 700 meters) from the station or track and on homes that are 2,300 to 5,280 feet (one mile) from the station. Several studies on other light-rail systems restricted their analyses to homes within 2,300 feet of a light-rail station. The square of the distance from each home to a station or track is also included in the model to capture a nonlinear relationship between distance and home values.*

Table 12—MetroLink's Impact on Residential Property Values

	Accessibility Effect (Distance to Station)	Nuisance Effect (Distance to Track)
Model 1	No effect	No effect
Model 2	No effect	No effect
Model 3	No effect	No effect
Model 4	No effect	No effect
Model 5	Average house price increases $138.10 for every 10 feet closer to MetroLink station, beginning at 1,470 feet. Average house price increases $67.16 for every 10 feet farther from station from 1,480 to 2,300 feet. There is no effect beyond 2,300 feet.	Average house price increases $12.25 for every 10 feet farther from MetroLink track between 2,300 and 2,820 feet. Average house price falls $53.75 for every 10 feet farther from track from 2,820 feet to one mile. There is no effect closer than 2,300 feet.
Model 6	Average house price increases $140.15 for every 10 feet closer to MetroLink station, beginning at 1,480 feet. Average house price increases $67.12 for every 10 feet farther from station from 1,490 feet to 2,300 feet. There is no effect beyond 2,300 feet.	Average house price increases $12.03 for every 10 feet farther from MetroLink track between 2,300 and 2,800 feet. Average house price falls $55.00 for every 10 feet farther from track from 2,810 feet to one mile. There is no effect closer than 2,300 feet.
Model 7	Average house price increases $137.95 for every 10 feet closer to MetroLink station, beginning at 1,440 feet. Average house price increases $72.49 for every 10 feet farther from station from 1,450 feet to 2,300 feet. There is no effect beyond 2,300 feet.	No effect
Model 8	Average house price increases $143.49 for every 10 feet closer to MetroLink station, beginning at 1,450 feet. Average house price increases $72.37 for every 10 feet farther from station from 1,450 feet to 2,300 feet. There is no effect beyond 2,300 feet.	No effect

Note: The average price for homes within 2,300 feet (≈ 700 meters) of a MetroLink station is $63,564, and the average price for homes beyond 2,300 feet of the MetroLink track is $86,856. Model complexity increases with model number; so, Model 8 is the preferred specification. See the appendix for a description of each of the empirical models. "No effect" means the estimated coefficients on the distance variables were not statistically different from zero.

Figure 3—MetroLink and Property Values: Accessibility and Nuisance Effects



similar to the one conducted here may provide different results regarding accessibility. Second, the results of any model are only as good as model specification. Although much care has been taken to correctly specify numerous house price models, the sample design, estimation error and data quality may affect the estimates. However, the estimates appear robust across model specification; so, it is unlikely that these problems, if they do exist, caused a significant bias in the results.

In summary, there is weak evidence of a nuisance effect associated with MetroLink; when it is found, it is very small. Thus, homes do not appear to experience a loss in value as a result of being located near MetroLink tracks. On the other hand, there is strong evidence of a relatively larger accessibility effect—home prices generally rise as distance to a MetroLink station decreases. This positive accessibility effect outweighs the negative nuisance effect; so, the net effect of MetroLink on property values is generally positive.

The study here should not be the definitive analysis on the impact of MetroLink on St. Louis County home values. Future studies could allow for the possible time lag in capitalization of accessibility into home prices. Also, the study area could be expanded to the city of St. Louis and East St. Louis. These are very different areas from St. Louis County, and it would be inappropriate to generalize the results here to other areas of St. Louis.

VI. Summary and Conclusions

This report provides an overview of light-rail transit in America. Much of the policy debate over light-rail transit involves several key issues, which were discussed in detail throughout the report. These issues include job creation, reducing pollution and traffic congestion, and financial solvency. Detailed statistics on the cost-efficiency of light rail vs. automobile and other public transit systems were also presented. Although it is clear that light rail and other public transit systems are less cost-efficient than private transportation, the benefits of light-rail transit—such as aesthetics, providing transit for the poor, potential economic development spillovers, and reducing congestion and pollution—must all be considered in the cost-benefit analysis of light rail.[41]

Economic development is the most important issue surrounding light rail, and it is also the most debated. This report spent considerable time discussing the potential for light rail to foster economic development, either through new construction or increases in existing residential and commercial property values. The general consensus from the academic literature and the findings presented in this report is that light rail is not a catalyst for economic development, but rather light rail can help guide economic development. Rather than relying solely on light rail to create economic development, city planners and officials should first address a key question: Why is economic development not occurring in a given area in the first place? Possible reasons include relatively high cost to business start-ups, unattractive locations (crime, poor infrastructure) and unnecessary zoning and regulations. Unless these barriers are lowered or removed, the long-run economic development objectives, with or without light rail, will not fully be met.

More cities will undoubtedly choose to adopt light rail or expand light-rail systems in the future. This is not a low-cost endeavor. Although politics certainly plays a role in the planning and construction of any public project, it is truly important for city officials and the citizenry to be educated on all aspects of light rail when debating the issue. Hopefully, this report has provided the necessary background on which to begin such debate.

Appendix

MetroLink and Residential Property Values: Empirical Methodology

A hedonic pricing model is used to estimate how distance from a MetroLink station or track affects property values. These models have frequently been used to estimate the effect of light rail on property values. Hedonic models relate the price of a good (in this case houses) to the individual attributes of the good (house and neighborhood characteristics).[42] The estimated coefficient on each attribute reveals the marginal contribution of that attribute to the price of the good.

The MetroLink analysis uses data on 1,516 homes in St. Louis County that sold in the years 1998 to 2001. All homes are within one mile of a MetroLink station. The full hedonic price model used in this study is represented as:

$$P_i = \alpha_0 + \alpha \cdot H_i + \beta \cdot N_i + \delta \cdot Z_i + \gamma \cdot D_i + \varepsilon_i$$

Where P_i is the sales price of house i, H_i is a matrix of house characteristics (see Table 11, yes/no is denoted with a binary dummy variable having a value of 1 if yes, 0 otherwise), N_i is a matrix of neighborhood characteristics (Table 11), Z_i is a matrix of 25-city dummy variables and three year dummy variables (one city and one year dummy were omitted to avoid identification problems), and D_i is a matrix of distance variables (in feet).

Two categories of distance variables are created—distance from track and distance from station. The variables are constructed to capture (1) the effect of distance on homes located 0 to 2,300 feet (≈ 700 meters) from a station and track (two variables), and (2) the effect of distance on homes located 2,300 feet to 5,280 feet (one mile) from a station and track (two variables). Each of these four variables is then squared and included in the model to capture the potential nonlinear relationship between distance and property values. Thus, there are a total of eight distance variables in D_i.

The hedonic price model also accounts for spatial correlation in house prices (the dependent variable) and the error term, ε_i.[43] Accounting for spatial correlation in the hedonic price model can improve the reliability and statistical strength of the estimates. Effective modeling of spatial correlation requires the creation of a weights matrix that reflects a spatial relationship between units of observation (in this case houses). An inverse distance weight matrix is used here, with the distance (in feet) between each observation computed by using the latitude and longitude of each house. Multiple observations per house (i.e., the house sold more than one time over the 1998 to 2001 sample period) resulted in nondiagonal elements of the weights matrix having a value of zero, which hindered proper estimation of the spatial models. These homes were dropped from the analysis.

Functional form is an issue with hedonic modeling. Since economic theory provides no insights into the proper functional form of any hedonic model, Box-Cox tests for functional form were conducted.[44] Results of the Box-Cox tests suggest a log-linear model. Thus, in all models house prices were converted to natural logarithms.

In all, eight models were estimated. Model complexity increases with model number. The models are summarized in Table A1. The results from each model can be obtained from the author.

Table A1–Variables Included/Excluded from Hedonic Price Models

	Distance to Track/Station	Home Characteristics	Neighborhood Characteristics	Year Dummy Variables	City Dummy Variables	Spatial Correlation in Dependent Variable	Spatial Correlation in Error Term
Model 1	Yes	Yes	Yes	Yes	No	No	No
Model 2	Yes	Yes	Yes	Yes	No	Yes	No
Model 3	Yes	Yes	Yes	Yes	No	No	Yes
Model 4	Yes	Yes	Yes	Yes	No	Yes	Yes
Model 5	Yes	Yes	Yes	Yes	Yes	No	No
Model 6	Yes	Yes	Yes	Yes	Yes	Yes	No
Model 7	Yes	Yes	Yes	Yes	Yes	No	Yes
Model 8	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: "Yes" denotes that variables were included in model. "No" denotes that variables were excluded from model. The estimates from each model can be obtained by contacting the author.

Endnotes

1 Data on rail transit and other public transportation systems are from the Federal Transit Administration's *National Transit Database*, available at www.ntdprogram.com. Automobile data are from the Federal Highway Administration's *Highway Statistics* available at www.fhwa.dot.gov/ policy/ohpi. "Vehicle miles" is the total mileage traveled by all vehicles of a particular type in a given time period. "Passenger miles" is the sum of miles traveled by all passengers in a given time period.

2 The American Public Transportation Association and www.heritagetrolley.org provide good descriptions of rail transit systems.

3 A more detailed history of rail transit and public transportation can be found in Kenneth T. Jackson's *Crabgrass Frontier: The Suburbanization of the United States*, Oxford University Press, 1985, and at the History Channel's web site, www.historychannel.com, using "public transportation" as the keyword for the search.

4 Early horsecars were also called omnibuses.

5 The 180 million passengers per year is about 493,000 per day; so, given that the 1880 U.S. urban population was 14,100,000, roughly 3.5 percent of all urban residents rode light rail [(493,000/14,100,00)*100].

6 Computed using chained GNP deflator values. The deflator for 1875 is from Appendix B in *The American Business Cycle: Continuity and Change*, edited by Robert J. Gordon, The University of Chicago Press, 1986, and the deflator for 2003 is from a Federal Reserve Bank of St. Louis web site, http://research.stlouisfed.org/fred2/data/GNPDEF.txt.

7 This refers only to the tax costs associated with operating costs. As discussed later, there are also tax costs associated with light-rail capital (construction) costs.

8 These are definitions used by the Federal Transit Administration in its *National Transit Database*.

9 This supports previous academic research that finds rail transit ridership is greatest in more densely populated areas. See Gordon, Peter and Willson, Richard. "The Determinants of Fixed Rail Transit Demand – An International Cross-Sectional Comparison," a chapter in K. Button and D.E. Pittfield, eds., *International Railway Economics*. Hants, England: Gower, 1985, pp. 159-75.

10 Rubin, Thomas A. and Moore, James E. "Ten Transit Myths: Misperceptions about Rail Transit in Los Angeles and the Nation." *Policy Study 218*, Reason Public Policy Institute, November 1996.

11 American Public Transit Association. *Transit Fact Book*, Washington, D.C. 1993.

12 Schrank, David and Lomax, Tim. *The 2002 Urban Mobility Report*. Texas Transportation Institute, Texas A&M University, June 2002. Available at http://mobility.tamu.edu.

13 Gordon, Peter and Willson, Richard. "The Determinants of Fixed Rail Transit Demand – An International Cross-Sectional Comparison," a chapter in K. Button and D.E. Pittfield, eds., *International Railway Economics*. Hants, England: Gower, 1985, pp. 159-75.

14 The point here is not to serve as an advocate for toll roads, but rather to highlight the important point that traffic congestion can only be reduced if drivers are forced to bear the costs they incur on other drivers. Toll roads are simply one way of doing this. For a more detailed discussion on reducing traffic congestion and improving urban transportation, see Winston, Clifford. "Have Car Won't Travel; The Sober – and Sobering – Case for Privatizing Urban Transportation." The Milken Institute Review, April 1999. Available at www.brookings.edu/views/articles/winston/19990826.htm.

15 2001 *National Transit Database*.

16 Revenue from other sources, such as advertising and private donations, accounts for roughly 7 percent of light-rail revenue nationwide.

17 In the short run, the number of potential riders is fixed, and consumers respond to fare changes by only changing their modal choice or the number of trips. In the long run, changes in fares affect ridership through choice of residence, job location and private transportation spending. See Voith, Richard. "The Long-Run Elasticity of Demand for Commuter Rail Transportation." *Journal of Urban Economics*, Vol. 30, 1991, pp. 360-72.

18 Barzel, Yoram and Silberberg, Eugene. "Is the Act of Voting Rational?" *Public Choice*, Vol. 16, Fall 1973, pp. 51-58; and Kelman, Steven. "Public Choice and Public Spirit." *Public Interest*, Vol. 87, 1987, pp. 80-94.

19 For a detailed cost comparison of automobile, light rail and bus transit, see Boyd, Hayden; Asher, Norman; and Wetzler, Elliot. "Nontechnical Innovation in Urban Transit: A Comparison of Some Alternatives." *Journal of Urban Economics*, Vol. 5, 1978, pp. 1-20. The authors also discuss the inefficient pricing of private automobile transportation and how pricing below cost will result in rail transit's having little impact on enticing riders and reducing traffic congestion.

20 American Automobile Association, *Your Driving Costs*, 2001 Edition, Heathrow, Fla. Available at wwwcta.ornl.gov/data/tedb22/Spreadsheets/Table5_12.xls. To compute automobile operating cost per passenger mile, the cost per vehicle mile was multiplied by 0.6289, which is the ratio of car vehicle miles to car passenger miles in Table 6.

21 As pointed out earlier, automobile usage places an additional cost on other drivers through increased congestion and pollution. This external cost is not considered in the operating cost figures in Table 6. If one considers this cost, the difference between automobile and light-rail operating cost per passenger mile is much smaller. According to Todd Litman's *Transportation Cost Analysis: Techniques, Estimates, and Implications*, Victoria Transport Policy Institute, June 2002, the cost of driving can range from about 10 cents per mile in rural areas to more than 30 cents per mile in urban areas. See www.vtpi.org/tca.

22 This correlation may not hold in large urban areas like New York or Chicago, where many well-to-do professionals take heavy-rail transit to and from work. However, in less densely populated cities, such as St. Louis, this correlation is much more likely. See Liao, Yihua. "Vehicle Ownership Patterns of American Households." University of Illinois at Chicago, Urban Transportation Center, Fall 2002.

23 There is evidence in support of this assumption. Roughly 30 percent of MetroLink riders earn less than $25,000 a year, according to Citizens for Modern Transit, "A New Way to Grow," p. 5, (www.cmt-stl.org). According to the 2004 Federal Poverty Guidelines (http://aspe.hhs.gov/poverty/04poverty.shtml), a family of two earning less than $12,490 is considered poor. The average family size in the United States is 2.5 persons. Thus, of the 30 percent of MetroLink riders making less than $25,000 a year, on average roughly half are officially poor ($12,490/$25,000 ≈ ½). If half of MetroLink riders making less than $25,000 a year are considered poor, then 15 percent of all riders could be considered poor, which is close to the 14 percent approximation used in the above example.

24 The total number of registered vehicles in St. Louis city, St. Louis County and St. Clair County (the most populated areas of the St. Louis metro area) is about 1.4 million. Adding 7,700 to this number results in about a 0.5 percent increase in the number of registered vehicles on the roadways.

25 The study can be found at www.publicpurpose.com/ut-newcar.htm.

26 Mills, E. "An Aggregate Model of Resource Allocation in Metropolitan Areas." *American Economic Review*, Vol. 57, 1967, pp. 197-210; Alonso, W. *Location and Land Use: Toward a General Theory of Land Rent*. Cambridge, Mass: Harvard University Press, 1964; and Muth, R. *Cities and Housing: The Spatial Patterns of Urban Residential Land Use*. Chicago: Chicago University Press, 1969.

27 Several of the studies in Table 8 have separated the nuisance and accessibility effects (Chen et al., 1998, for example).

28 Meyer, J.R.; Meyer, J.A.; and Gomez-Ibanez, J.A. *Autos, Transit, and Cities*, Cambridge, Mass.: Harvard University Press, 1981; Giuliano, G. "Land-Use Impacts of Transportation Investments: Highway and Transit," in S. Hanson, ed., *The Geography of Urban Transportation*. New York City: Guildford Press, 1986; Giuliano, G. "Research Policy and Review 27: New Directions for Understanding Transportation and Land Use," *Environment and Planning*, Vol. 21, 1989, pp. 145-59.

29 Landis, John; Subhrajit, Guhathakurta; and Ming, Zang, "Capitalization of Transit Investments into Single Family Home Prices." Working Paper 619, Institute of Urban and Regional Development, University of California at Berkeley, July 1994.

30 Dornbusch, David M. "BART-Induced Changes in Property Values and Rents." *Land-Use and Urban Development Projects, Phase I, BART*. Working Papers WP 21-5-76. U.S. Department of Transportation and U.S. Department of Housing and Urban Development, Washington, D.C., 1975; Blayney (John) Associates/David M. Dornbusch and Co. Inc., *Land-Use and Urban Development Impacts of BART*. San Francisco: Metropolitan Transportation Commission, 1979.

31 Cervero, Robert. "Rail Transit and Joint Economic Development." *Journal of the American Planning Association*, Vol. 60, No. 1. Winter 1994, pp. 83-94.

32 ibid.

33 ibid.

34 ibid.

35 Statistics in this section were obtained from Metro's *2003 Comprehensive Financial Annual Report*, available at www.metrostlouis.org/MetroNews/FinancialDisclosure/financialreports.asp.

36 Park-and-ride lots allow drivers to park their cars near a light-rail station.

37 From the 2002 *National Transit Database*. Specific funding sources for individual transit systems, such as bus and MetroLink, are not available.

38 An analysis could not be conducted on homes in St. Louis city because of incomplete data on housing characteristics. The period 1998 to 2001 was chosen to allow any capitalization of MetroLink on property values to occur since MetroLink's inception in 1993. Several studies have suggested that there is a time lag between the introduction of light rail and its impact (if any) on property values.

39 Chen, Hong; Rufolo, Anthony; and Dueker, Kenneth J. "Measuring the Impact of Light Rail Systems on Single-Family Home Values: A Hedonic Approach with Geographic Information System Application." *Transportation Research Record*, Vol. 1,617, 1998, pp. 38-43.

40 For homes that sold more than once during the sample period 1998 to 2001, only the first sale is included in the models. As discussed in the appendix, the models could not be estimated with multiple observations per house.

41 Litman, Todd. Two reports from the Victoria Transit Policy Institute, Victoria, British Columbia: 1) "Comprehensive Evaluation of Rail Transit Benefits." May 12, 2004. See www.vtpi.org/railben.pdf. (2) "Evaluating Public Transit Benefits and Costs." July 20, 2004. See www.vtpi.org/transben/pdf.

42 Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, Vol. 82, No. 1, January/February 1974, pp. 34-55.

43 Anselin, Luc. *Spatial Econometrics: Methods and Models*. Dordrecht, the Netherlands: Kluwer Academic Publishers, 1988, for a discussion of spatial econometric methods.

44 Box, G. and Cox, D. "An Analysis of Transformations," *Journal of the Royal Statistical Society: Series B.*, Vol. 26, 1964, pp. 211-43.

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