Evaluating the Costs and Benefits of Increased Funding for Public Transportation in Chicago

by

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Abstract

The Chicago Transit Authority (CTA) faces an immediate financial crisis and a long-term struggle to maintain its role as a meaningful transportation provider in Chicago. Political and financial constraints will induce significant ridership losses in the near term unless additional operating funds are made available. Moreover, even if funding for current fares and service levels is maintained, the CTA risks a continuing decline in market share unless additional action is taken.

This thesis investigates the costs and benefits of increased funding for the Chicago Transit Authority under various scenarios. First, it examines historical and political factors that have created the current tenuous environment for public transportation in Chicago. Then, it establishes a framework for assessing the potential effects of increased funding. A distinction is emphasized between measures that are internal to the agency, such as cost-effectiveness, and external measures of benefit to riders and the region. A simplified, strategic cost-benefit framework is outlined, focusing on three major benefit categories that drive political decision-making: transit rider mobility (or generalized cost), congestion mitigation, and regional air quality.

Examination of the likely near-term effects of the financial crisis shows that additional funding is clearly justified in order to avoid the projected fare increases and ridership losses, even when the costs of public funding are included. However, achieving additional ridership growth through endogenous agency action is more difficult. It could be achieved through fare reductions, but political constraints make such a move unlikely. A straightforward expansion of service, even if targeted at buses and more responsive off-peak ridership, is at or slightly below break-even with respect to net benefits if the CTA cost structure and tax source of subsidy remains unchanged. In order to justify any significant additional long-term funding for the purpose of growing ridership, the CTA should make operational changes to lower its costs and should seek additional funding from sources with lower societal costs.

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1 Introduction: Thesis Problem and Overview

The Chicago Transit Authority (CTA) faces an immediate financial crisis and a long-term struggle to maintain its role as a meaningful transportation provider in Chicago. Some of the origins of this tenuous position are deeply historical, but present-day political and financial constraints are also major causal factors. These constraints will induce significant ridership losses in the near term unless additional public operating funds are made available. Moreover, even if funding for current fares and service levels is maintained, the CTA risks a continuing decline in market share unless additional action is taken. This thesis will evaluate the likely impacts of various future funding scenarios for the CTA and make strategic policy recommendations based on that analysis.

1.1 The Problem

To a degree exceeded in the U.S. only in metropolitan New York, the Regional Transportation Authority of northeastern Illinois (including CTA, Metra commuter rail, and Pace suburban bus) is a significant provider of mobility and accessibility in the Chicago region. For low-income and disadvantaged households, transit (especially the CTA) provides basic transportation, but it also provides congestion mitigation, air quality, and option value benefits that accrue to citizens across the metro area. More than 20% of workers in Cook County (the central county in the Chicago metro area) use transit for their commute, and nearly 1.5 million daily rides are carried on CTA trains and buses on an average workday.

Despite this important role, the CTA has faced funding and ridership crises throughout its postwar history, and it faces another in 2005-06. Because of slow sales tax revenue growth and increasing costs, the CTA (according to internal projections) faces an unfunded operating deficit of almost $50 million in 2005. This deficit exists despite the fact that the CTA increased its base fare from $1.50 to $1.75 at the end of 2003 to avoid a financial crunch. While this increase was unfortunate for riders, it was not inconsistent considering inflation and base fares at peer agencies. Yet the CTA still faces an operational crisis, and if the current funding structure remains unchanged, additional significant fare increases and/or cuts in service will be required in order to meet the RTA's fare recovery ratio requirement.

This crisis is not occurring because of a deterioration in operating performance. The CTA's operating efficiency and service effectiveness have been steady and comparable to peer agencies since 1996 and ridership has increased modestly. Instead, the crisis arises from overall public
funding that (a) is increasing at a rate below inflation and (b) is unrelated to ridership, and from service requirements for paratransit added with no additional funding and no exemption from the strict farebox recovery ratio.

It is instructive to consider the funding and ridership experience of the CTA over the past quarter century under the oversight of the RTA (see Figure 1-1). Chicago was considered one of the nation’s “best” transit properties in the immediate postwar years. Yet the ridership losses in Chicago have been especially heavy – more than 30% since 1979 – while national transit ridership during the same period has been steadily increasing. From a low of 6.5 billion annual trips in 1972, national transit ridership has increased by more than 50% to 9.7 billion trips in 2001.

![Figure 1-1: Total CTA Ridership and Federal Funding, 1978-2002](image)

Striking changes in the provision of transit service by mode also occurred in Chicago during this period. As funding became constrained and various financial crises hit the agency, service reductions were often instituted. In almost all cases, these cutbacks were focused on the bus network, the carrier of the majority of Chicago’s transit patrons. Figure 1-2 shows ridership and
revenue vehicle miles separately for motorbus and rail rapid transit across the same period. Rail transit actually showed a net growth in revenue service over the period, as the Orange Line was opened in 1993 and improvements in efficiency (especially the move to one-person train operation) allowed additional service provision for the same expenditure level. As a result, ridership also held virtually constant over the period, dipping slightly during the worst years of the early 1990s but recovering later in the decade. The bus experience is sharply different, as both ridership and revenue service trended steadily downward until 1998 – revenue vehicle miles were reduced by 18% and ridership fell by more than 45%.

![Figure 1-2: CTA Ridership and Revenue Miles, by Mode, 1978-2002](image-url)

Many demographic and economic factors were certainly causally related to this drop – the population loss to the suburbs was especially strong in Chicago during the period, and shifts in employment and retail locations made the automobile relatively more attractive. However, service reductions resulting from operational funding constraints must also be counted among the causal factors. Real federal operational funding (in 2003 dollars), which had averaged over $85 million annually from 1982-1986 (after peaking at almost $140 million in 1979) and was still
as high as $50 million in 1994, was zeroed out during the late 1990s. Yet no changes were made to the regional structural funding arrangement to account for this reduction. The CTA also was not reimbursed for some discounted fares throughout the 1990s, and it faces a large and growing financial burden from providing paratransit service to the disabled (estimated at $45 million for 2004). Though we cannot reverse the past, Chicago's experience should serve as a warning for the future regarding the effect of diminished funding on ridership.

And yet ridership in itself, while indicative, is not a complete measure. The ridership lost during past crises was costly because:

- Many trips shifted to the auto, increasing regional roadway congestion and decreasing air quality.
- Some trips were completely abandoned, destroying mobility for those travelers.
- Continuing transit riders suffered increased user costs (i.e., loss of consumer welfare) as fares were increased and service was reduced.
- Transit's "option" value to infrequent riders was reduced as it became less competitive with the auto.

This thesis will attempt to measure the costs and benefits associated with avoiding such ridership loss during the upcoming years. Avoiding this loss will require additional public funding. This thesis does not focus on the very real considerations of the source of this public funding. Instead, we are interested in the costs and benefits of addressing the crisis - how different levels of funding will achieve different outcomes.

1.2 Thesis Overview

1.2.1 Background

In Chapter Two, we provide an in-depth discussion the evolution of surface transportation in Chicago and of the problems facing the CTA. These problems have both historical origins (rooted in divergent public policies towards mass transportation and the private automobile) and current causes (the structural allocation of regional transit funding). This chapter will help to take the cost/benefit analysis out of the abstract and ground it in the particular realities of metropolitan Chicago.

Readers interested in this question should refer to the 2004 MIT masters' thesis of Julie Kirschbaum, "Show Me The Money: Paying For Transit Operations At The Chicago Transit Authority."
1.2.2 Framework

In Chapter Three, we create a framework for assessing the potential investments and expenditures to address the problems. As part of this evaluation framework, we consider both internal and external measures of transit performance. Literature on both performance aspects is reviewed, and we compare the recent performance of the CTA with three of its peer U.S. transit agencies (in Boston, Houston, and Washington, DC). Finally, we review various approaches taken toward benefit/cost analysis in the literature and by government agencies at both the state and federal level, and we describe the major benefit areas we will consider in the analysis.

1.2.3 Baseline

In assessing the impact of the immediate financial crisis on the region, we must first examine the costs of doing nothing. Chapter Four examines the prior experience of the CTA when forced to implement fare increases, which have generally had a highly negative impact on ridership despite raising overall revenue. We then evaluate the estimated additional subsidy requirements to maintain ridership against the mobility, congestion, and air quality losses that are likely to occur if that subsidy is not available.

1.2.4 Ridership Generation

Having established a justification for raising baseline funding for the CTA in order to maintain ridership, in Chapter Five we consider further investments and expenditures aimed at increasing ridership. We examine three potential policy objectives: holding congestion levels constant by diverting regional vehicle miles traveled (VMT) growth into transit; reducing household automobile expenditures; and recapturing previous levels of ridership. Using a strategic-level cost model, we evaluate simplified one-period costs of achieving these goals and also identify constraints on the CTA that prevent particular objectives from being realized. We also examine the possibility of increasing ridership from fare reduction and differentiation.

1.2.5 Evaluation Over Time

The one-period cost model of the previous chapter tells only part of the story. In Chapter Six, we evaluate the multi-period benefits and costs of adding ridership in an attempt to answer whether it is worth it to achieve greater levels of ridership through endogenous actions by the transit agency. There are clearly benefits that accrue from increased ridership, though the net
benefits of a straightforward expansion of current service patterns appear to be at or slightly below the breakeven point. We then examine possibilities for altering the operating environment in order to make the investments and expenditures more effective.

1.2.6 Recommendations and Future Research

In the final chapter, we assess the lessons learned from the previous analyses, make policy recommendations for the CTA based on those results, and outline future research topics that build on this thesis.
2 Background: The Public Transit Environment

Urban mass transportation in the United States is overwhelmingly a publicly-provided good. In this chapter, the causes and implications of this situation are examined more closely, first with a brief look at national transit trends and then with a specific focus on the historical evolution of public transit in Chicago. From this examination, three themes emerge which will shape the analysis in the rest of the thesis:

A. The relative shares of mass transit and the private automobile for surface passenger trips have never been, and likely never will be, determined purely by market forces. The actions of government, from traffic laws to tax structures, place constraints on the transportation system, which in turn have dictated outcomes. It is proper to examine how these policy and funding constraints might be shifted to obtain different outcomes. It is especially appropriate given the uncompensated externalities – notably congestion and air pollution – associated with motor vehicle usage.

B. Metropolitan areas across the country continue to experience increases in vehicle miles traveled and rush-hour congestion. This congestion is costly not only for travelers (lost time and excess fuel), but also for surface freight carriers. Especially in major metro areas, public transit plays a significant role in mitigating these losses.

C. Regional decision-making with regard to public transit has many positive features, but it can sometimes lead to perverse outcomes. The costs and benefits of “buying back” additional transit trips will depend heavily on what kind of additional service is purchased and on what funding constraints exist for the agency.

2.1 Public Transit in the U.S.: A Brief Overview

The second half of the 1990s was a period of modestly strong growth for public transit in the United States, a turnaround after decades of slumping ridership and declining finances. Transit ridership peaked in the immediate postwar years with over 23 billion trips in 1946 (when the national population was only 140 million), but the steady advance of the automobile and the significant movement of households and jobs into lower-density suburbs decimated many transit providers. A vicious cycle began, where increasing road congestion induced many employers and households to decentralize further, which both hurt transit and ultimately contributed to more congestion. Local and state governments were forced to take over these companies and support them with public funds in order to guarantee some continuation of
service. Yet local public funding could not halt the decline, and the federal government joined in supporting transit through the Urban Mass Transportation Act of 1964 and subsequent legislation.²

The low point for transit ridership came in 1972, when only 6.6 billion trips were recorded, an absolute drop of over 70% from the postwar high and an even greater fall-off in per-capita terms. During the 1970s, ridership did improve as significant capital funds were expended on transit, especially on new heavy rail systems in cities like San Francisco and Washington, DC. By 1985, total transit ridership stood at 8.4 billion annual trips. For the next ten years, however, federal spending for capital and operating support fell in real terms, and the ridership trend returned to negative, with a billion annual trips lost in that period. But the combination of a resurgent national economy and improvement in public support (through the ISTEA and TEA-21 federal authorization bills) gave transit a strong push in the late 1990s. By 2001, steady growth had lifted total transit ridership to 9.0 billion rides, an increase of 20% over 1995.

Gross ridership numbers do not tell the entire story, of course, since ridership increases can result from both extended service on the supply side and increased intensity of use on the demand side. In the ten years from 1991 to 2001, total vehicle revenue miles (VRM) by transit vehicles increased by one-third, from 2.5 billion to 3.3 billion. This increase was not spread equally across all modes. Buses, which provide the majority of transit service in the U.S., saw VRM increase 17%, and nearly all of that increase has been since 1996. Heavy rail VRM was also up 17%, though the growth was more gradual across the period. Modes such as light rail, vanpool, and demand responsive (paratransit) service saw much higher percentage increases, though on a smaller base of riders. Thus, it is clear that intensity of use for transit has actually fallen substantially over the last ten years. Considered across all modes, ridership from 1991-2001 increased by 16%, but total vehicle revenue hours (VRH) increased by 34%, essentially the same as VRM. This corresponds to a decline of 13% in ridership per VRH, which is a worrying trend. When considered specifically by mode, the picture is only slightly brighter. Bus, heavy rail, and commuter rail all declined between 5% and 10% in ridership per VRH during those years.³

² See, for example, the American Public Transportation Association's (APTA) history of public transit for additional information (http://www.apta.com/research/stats/history/mileston.cfm).
³ Comprehensive data on revenue seat miles, which would give a clearer picture of total transit capacity being supplied, are not readily available. In its annual conditions and performance report, the Federal Highway Administration (FHWA) calculates a measure of transit utilization for each mode: the ratio of
Public transit agencies must be concerned not only with the usage of transit, but also the cost of providing it. Transit is heavily labor-intensive, with salaries, wages, and fringe benefits accounting for 80% of the operational spending on transit in the U.S. For a number of reasons, including the strength of labor unions in local politics and the labor protection provisions of the Urban Mass Transportation Act, transit labor expenses have been especially burdensome in the post-war period. However, the operating expenses for public transit have been moderated somewhat in the previous ten years, as operating expense per unlinked trip has grown at just below the rate of inflation. It is also instructive to compare per-trip operating costs for various modes. As of 2001, the average passenger trip on heavy rail in the U.S. required $1.50 in operating expenses, and the average bus trip cost $2.30. By comparison, commuter rail service—which saw significant expansion in many cities during the 1990s—cost $6.80 per passenger trip, though trips on commuter rail are generally longer than bus or heavy rail trips. Of course, these national averages obscure many differences between and even within transit agencies, and these differences affect the ease with which an agency might begin to “buy back” trips.4

Despite the recent positive signs of increases in transit ridership and slower growth in operating expenses per passenger trip, a larger concern exists for public transit—an increasing marginalization compared to the private automobile. Considering both cost per trip and service frequency, mass transit has always been most effective in serving radially-oriented trips and trips during high-volume times of day. In practice, this has meant focusing most service on peak-hour commuting trips, and the overwhelming dominance of the private auto for non-work trips by choice riders is not surprising. Yet the journey-to-work data from the United States Census shows that transit has steadily lost market share even for commuting trips. In 1960, public transit accounted for 12.6% of all trips to work, while private vehicles had 69.5% of the commuting market. By 2000, the auto accounted for 87.9% of work trips while transit captured vehicles operated in maximum service to total passenger miles, adjusted by a “capacity factor” that is not given. This measure shows heavy rail utilization rising slightly from 1987-2000 and bus utilization falling slightly. There are a number of problems with this approach; most notably, it ignores any changes in off-peak service provision. More information is available in Chapter 4 of the 2002 Conditions and Performance Report, FHWA, http://www.fhwa.dot.gov/policy/2002cpr/.

4 The growth in demand responsive services has been especially costly to agencies. Total demand responsive ridership has grown 50% from 1990 to 2002 (from 68 million to 103 million), and these trips had an average operating cost per trip of $18.90 in 2002 while only receiving an average fare per trip of $1.87 (APTA Statistics). This service, mandated by the federal Americans with Disabilities Act but unsupported by federal funds, is an increasing burden on transit agencies.
only 4.7%. Indeed, the number of workers commuting by transit was flat between 1990 and 2000 (6.1 million), but the total number of workers increased by over 13 million.

A simple overview of national transit trends, however, is insufficient to illuminate either the more specific causes of transit’s problems or the possibilities for its revival. As an introduction to the case study, a more comprehensive review of surface transportation’s development in Chicago is presented.

2.2 The Evolution of Surface Transportation in Chicago

The evolution of surface transportation in Chicago serves as a useful encapsulation of transit’s development in the United States. Chicago occupies a middle ground of sorts - unlike most large western and southern cities, its period of greatest growth was in the pre-automotive era, but it has a physical expansiveness not shared by older east coast cities. Of course, a number of the historical details are necessarily specific to Chicago, but the larger lessons are broadly applicable.

2.2.1 A City Built on Transportation

The city of Chicago covers an area of nearly 230 square miles in the northeastern corner of Illinois, directly west of Lake Michigan. As of the 2000 Census, nearly 2.9 million people called Chicago home, a four percent increase over 1990 which halted decades of population loss following World War II. The metropolitan area spreads much further – the nine-county Chicago PMSA covers 5,065 square miles and has approximately 8.3 million residents, an increase of over eleven percent since 1990. Chicago currently stands as the third largest metro area in the United States, behind New York and Los Angeles.

Chicago’s history is intimately tied to transportation. From its beginnings as a portage between Lake Michigan and the Mississippi River to its present position as a national hub for railroads and airlines, the movement of people and goods has been key to the growth of the city. As new transportation technologies have been developed, and as the funding and operation of transportation systems has evolved, Chicago has transformed along with them.

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5 Chicago’s population peaked in 1950 at 3.6 million and fell steadily thereafter despite the strong population growth in the overall metropolitan area. Between 1970 and 1990 alone, the population of the city of Chicago dropped by nearly 600,000 people.
6 The six largest counties in the PMSA, which are closest to Chicago and constitute the area under the jurisdiction of the Regional Transportation Authority (RTA), are Cook, DuPage, Lake, Will, Kane, and McHenry Counties. The three other counties (Grundy, DeKalb, and Kendall Counties) are outlying and contain only 2% of the metropolitan area population.
Chicago grew to national prominence in the pre-automotive age, when railroads hauled the majority of the nation’s freight and a system of privately owned streetcars and elevated railways moved travelers throughout the city. The basic form of the city was created in this period. Yet as the automobile gained market share in the 1920s and 30s, as interstate expressways into and around the city were built following World War II, and as zoning was changed to reduce densities and separate land uses, Chicago was altered as well. Both in the city and in the new suburbs, individual trip-makers increasingly opted for the convenience of the private automobile, while freight movers found the flexibility of trucking indispensable.

Now, at the beginning of the 21st century, a combination of private choices and public investments has created a dilemma. Mass transit, although reduced since its heyday, still plays a vital role in providing mobility and accessibility in Chicago, especially for the young, old, and disadvantaged, and it has the potential to do more. Trucking continues to grow, and the yard-to-yard movements that are a key determinant of the success of Chicago’s intermodal shipping business are a focus of great commercial interest. Yet current public choices in the allocation of financial and physical resources, which in turn influence private investment and consumption decisions, continue to focus on the mobility of the private automobile at the expense of these other modes. And still the congestion on highways and principal arterials continues to worsen.

2.2.2 The Pre-Automotive Era

The land at the southwest corner of Lake Michigan was home for centuries to Native American tribes. But when the Treaty of Greenville in 1795 ceded a piece of land at the mouth of a slow-moving river to the nascent United States, the creation of Chicago was set in motion. The land was originally the site of Fort Dearborn, a garrison for the soldiers who protected the traders and trappers of frontier America in the early 19th century. As the dangers waned and the trading volumes grew, the need for a canal to connect Lake Michigan to the Mississippi River became apparent. As explained by Cronon, after rejecting an easier route via the Calumet River, which would have benefited Indiana at the expense of Illinois, the “canal town” of Chicago was platted in 1830 and formally incorporated in 1833. As work on the canal continued and the population grew, the town became a city in 1837. By 1848, when the Illinois & Michigan Canal was finally completed, Chicago was on the verge of tremendous growth.
2.2.2.1 Trade And Urban Form

Even before the I&M Canal, farmers from the surrounding prairie found that the cheap access to eastern cities via the Great Lakes meant better prices for their grain in Chicago than elsewhere. They brought the grain to the city in horse-drawn wagons and sold it on the banks of the river. Miller describes how, once the canal opened, creating a continuous water route between New York and the Gulf of Mexico, Chicago became the central point for a much larger universe of trade between the urban manufacturing centers of the East and the resource-rich states and territories of the West and South.

Many other goods besides grain came into Chicago on the canal, including cotton, molasses, and other southern commodities from far down the Mississippi. Water-borne freight also came in from the north and east, and Great Lakes shipping was another key to Chicago’s strength. Lumber from Wisconsin, iron ore from Minnesota, and coal from Pennsylvania came into Chicago’s harbor, providing the raw materials for the growth of housing and industry. Grain exchanges, mills, storage silos, and other industrial buildings filled the banks of the Chicago River, creating the first iteration of the dense downtown area that still draws travelers and freight today.

Ultimately, the canal and the lake boats were only setting the stage for the economic growth that would come in the second half of the 19th century. Chicago’s first railroad, the Chicago & Galena, was started in 1848, just as the canal was completed. Less than a decade later, Chicago possessed a 3,000-mile rail network, the largest in the world. Although they originally worked in parallel, the speed and capacity of the rails, as well as their ability to reach directly into the hinterlands, overwhelmed the water carriers. Goods could now be shipped to the East Coast in days rather than weeks, and specialized equipment such as refrigerated cars allowed Chicago to become the center of the country’s beef and pork trade. Competing lines soon crisscrossed the city in order to meet the demand.

Perhaps the most important of these lines for Chicago’s growth was the Illinois Central (IC), which covered the length of the state between Cairo (at the junction of the Mississippi and Ohio rivers) and its two termini at Chicago and Galena. Its completion in 1856 had two notable effects. First, it opened up downstate Illinois to farmers, creating another huge market for Chicago. Second, it allowed shippers to bypass St. Louis, Chicago’s principal competition for trade and industry. St. Louis failed to respond effectively, and Chicago quickly surpassed its rival to become the dominant Midwestern city.
The effect of the Illinois Central and the other railroads on Chicago’s urban form is striking. As Miller notes, Chicago did not have to adjust to the railroads as older cities did. It simply grew up with them. In some senses, this concurrent growth was quite negative. The railroads took up vast tracts of valuable land, spoiled the city with air and noise pollution, and snarled traffic and killed residents at hundreds of at-grade crossings. Yet without the railroads, the development of Chicago’s downtown core would have taken a different course. The competing railroads that headed out of Chicago to the east built massive yards to the south of the small central business district. These yards prevented a southward expansion of the downtown, which was the only direction available since the river and the lake blocked the north, west, and east. Unable to expand out, Chicago’s already dense Loop expanded upwards, and the American skyscraper was born.

The Illinois Central also helped shape the city’s form in another particularly notable way. Unable to enter the city to the west of downtown due to the presence of a rival, in 1852 the IC sought access via the lakefront. Yet the canal commissioners who had supervised the sale of land plots in 1836 had marked the lakefront property as being a “Public Ground - A Common to Remain Forever Open, Clear, and Free of Any Buildings, or Other Obstruction Whatever.” This single phrase became the bedrock upon which the protection of Chicago’s lakeshore was built. The IC counted on gaining the access in exchange for building and maintaining breakwaters that would protect the lakefront from storms. But the city ultimately granted the IC access into downtown on a trestle in Lake Michigan.

This decision soon took on a greater significance. After the fire of 1871, the burnt remains of the downtown were used as landfill between (and ultimately beyond) the shoreline and the railroad tracks, and acres of new land in the heart of the city were created. When the Illinois Central attempted to gain rights to this land for expanded rail operations, preservationists and others fought back. After many decades of fighting in the courts and the legislature, the prerogative of the city to keep its lakeshore open was upheld. This victory opened the way for Daniel Burnham, and his Plan of 1909 laid out a unified approach for organizing and beautifying the city that continues to influence decisions today.

2.2.2.2 Intra-City Freight

Like most cities of the 19th century, the bulk of Chicago’s freight within the city was moved with animal power. As the city grew in the years following the fire, the volume of both finished goods and raw materials increased tremendously, and the horse-drawn heavy wagon was the
standard mode for moving freight for decades until the adoption of the truck. The poor quality of the city's roads, in combination with the feeding, watering, and manure removal required for horses, made freight hauling difficult enough. But the heavy concentration of both manufacturing and retail in central Chicago, which drew hundreds of thousands of people to the area on foot and by transit, created congestion on a massive scale that threatened the city's economic capability (see Mayer, for example, for a more complete description).

Chicago did possess a unique transportation asset, however, that mitigated some of that congestion in the central business district. As described in detail by Moffat, from 1898 to 1902, the newly formed Illinois Telephone & Telegraph Company dug tunnels under the streets of downtown Chicago. These tunnels were ostensibly for new telephone lines, but the IT&T had a hidden plan to provide intra-city freight service on small, electrified rail lines. The plan eventually came to light, but a modified franchise was granted, and the Illinois Tunnel Company began revenue service on its 45 miles of tunnels in the summer of 1906.

The tunnels of the ITC connected rail yards, warehouses, offices, and department stores throughout downtown. The major source of revenue was coal, which supplied the energy for most buildings in the city, but cinders, baggage, and mail were also carried under the streets, and stores used it to ship small goods. Traffic was strong for many years, but a number of factors led to its eventual decline and closing in 1959. As the city expanded, surface railroads moved their yards farther away from the downtown, reducing the connective ability of the tunnels. Trucking, with its flexibility and reduced need for transshipment, took much of the business. And finally, the subway tunnels in the Loop were built during the 1930s and 40s with little regard for the freight tunnels, forcing the closure of many key links. Yet the tunnels remain a prime example of the value that can be realized from traffic segregation.

Outside of the downtown area, Chicago had another special transportation asset. Chicago's unique geographic position meant that many railroads chose the city as a terminus. Yet much freight still needed to travel through the city, which required laborious and time-consuming switching from one carrier to another. The Belt Railway Company of Chicago was formed in 1882 to serve this need. Under the joint ownership of five of the major railroads of the era, a system of rail tracks was constructed that linked all the major yards in the city, along with manufacturing areas on the south side. This system of convenient linkages allowed easy movement of freight and avoided the congestion of the city streets. In the early 20th century, the Belt Railway expanded along with the city as the rail yards moved further from the urban
center. The Belt Railway continues to serve the major rail terminals in Chicago, although in an attenuated form, as much of the inter-yard movement has shifted to the congested city streets via trucking.

2.2.2.3 The Movement of People

A singular feature of Chicago is its city street grid. Many cities have a partial or even complete grid, but few can match the regularity and vast expanse of Chicago. The dominance of the grid was born out of a combination of geography and economics, but its effect on the movement of people continues to shape the city and hold potential today.

With the first plat of the area around the river mouth in 1830 by James Thompson, the regular pattern for Chicago was set. It was easy to expand existing streets and boundaries because the flat prairie land offered few interfering geographic features. The regularity of the grid had a business advantage as well for Chicago. Rectangular lots were easy to survey and to sell, and this was key for a rapidly growing city. Some social historians (see Miller, for example) have criticized this growth pattern, deeming it beneficial only to the private speculators who sold and re-sold "commodified" pieces of land without regard to urban form. Yet its effect on transportation alone offers a partial response to that view.

When Chicago was young, it was a walking city, and development stayed close to the river and the lakeshore. But the horse-drawn omnibus enlarged the area open to development, and when rail tracks were put down on the heaviest routes, the city was further expanded. Thus, by 1871, just before the fire, Chicago’s grid was both a hindrance to the city and a facilitator of its growth. Only 88 of its 530 miles of streets were paved, and many of those were covered with manure and rubbish. Yet the streets and the railways on them provided unprecedented access to disparate parts of the Chicago area – the Union Stock Yards, Lincoln Park, and even the village of Hyde Park.

Tremendous growth in the grid and the transit network followed the fire. At the time of the World’s Columbian Exposition in 1893, the city was crisscrossed with both electric and horse-drawn street railways, cable cars, and the beginnings of an elevated railway network (a line running south from downtown to Jackson Park, built to carry visitors to the Exposition). The horse-drawn cars were on their way out, though, and the cable cars soon followed. Both were replaced by continued extensions in the electric streetcar and elevated railways systems. At the same time, improvements continued on the street system itself. By the turn of the century,
Chicago had nearly 1,400 miles of paved streets that spanned the city at regular mile ("section line") and half-mile intervals.

Despite the iconic stature of the 'el’ in Chicago, and without denying its significant value in providing accessibility, street-based modes have always carried the majority of transit traffic in the city, and the rectangular nature of the streets provides one reason why. Electric streetcars set the pattern, with routes on the section line streets and most of the half-mile streets and diagonals. This arrangement ensured that not only were a large majority of citizens in Chicago within walking distance of a streetcar route, but they also could make cross-town trips without traveling through downtown. Thus, despite the crowding and congestion travelers had to endure during a streetcar trip, the traffic on the lines continued to grow. In 1929, by which time the competing franchises had been organized into a single Chicago Surface Lines, the city boasted a system of nearly 1,000 miles that carried almost 890 million fares. But by then the automobile had arrived, and the city had already entered a new era.

2.2.3 The Auto Revolution

The automobile’s rise to dominance, both in Chicago and across the world, spans reasons of economics, technology, public policy, and sociology, and a full treatment here is clearly impossible. Yet Paul Barrett, in his excellent book "The Automobile and Urban Transit," gives insight into the alternate approaches taken toward transit and the automobile in Chicago during the first three decades of the 20th century, and his analysis helps to set the stage for understanding the present and future of ground transportation in the city. In addition, continuing advances in truck technology and the building of the interstate highway system encouraged a massive shift from rail to trucking. While not devastating to Chicago, this shift changed the needs and priorities of freight handling in the city.

2.2.3.1 Private And Public Responsibility

Mass transit in Chicago was, from its inception, conceived as a fundamentally private operation. In the 19th century, the system was decidedly laissez faire – transit lines owned by land speculators stretched into unsettled prairie in hopes of increasing land values, and companies competed vigorously over the most heavily traveled corridors. By the early 20th century, however, reaction against the crowded and disjointed system led to public action. Although some pressed for municipal ownership of the transit network, its continuing profitability (especially the streetcar lines) made that seem unnecessary to most. As described
most fully by Barrett, Chicago opted instead for regulated private ownership in an attempt to provide both acceptable service to riders and a reasonable return to transit investors. Long-term franchises were granted by the city, the ability of the streetcar and elevated companies to set fares was severely limited, and "rationalization" of service was encouraged.

While this compromise had some obvious benefits over unregulated competition and was viewed as a progressive model for other cities, it ultimately limited the ability of mass transit to respond to the growing competition of the private automobile. Strategic questions such as line extensions, equipment maintenance and replacement, and transfer policies became deeply politicized, and the battles took place between highly visible combatants. The desires of downtown businesses, outlying neighborhood associations, and the transit company itself might all be mutually exclusive, and some institutional paralysis was an unsurprising result.

The automobile, conversely, faced far fewer political demands. From the outset, and due in part to Burnham's Plan and to a national "good roads" movement, it was deemed a basic role of the city to improve and widen city streets. At the same time, regulation of the automobile was much more difficult than regulation of transit or even freight haulers, due to the dispersed ownership and usually high social standing of the early auto adopters. Finally, the simple advantages of personal automobility for the traveler should not be minimized. The advances in comfort, speed, and reliability, combined with zoning changes and accommodations that were made to allow parking even in crowded areas, made the auto undeniably attractive.

The growth in auto ownership in Chicago was striking. In 1915, the ratio of people to cars was sixty-one to one. Only five years later, the ratio had been halved, and by the onset of the Depression in 1930, there were only eight residents per private car. Auto traffic in both the CBD and the outer areas grew, and the transit lines found it increasingly difficult to compete. As traffic congestion worsened, streetcar performance deteriorated and many passengers switched to automobiles, beginning a vicious cycle that continues to plague street transit service. At the same time, inflation collided with the resolute demand by citizens and their representatives for a five-cent fare. The finances of the transit companies began to decline, and the quality of their private infrastructure suffered, further depressing transit's competitiveness.

The arrival of depression and war dealt the final blow to the faltering and overcapitalized private transit companies (see Cudahy and others). Chicago Rapid Transit (the now-unified elevated railway company) was forced into receivership in 1932, and the Chicago Surface Lines were also in receivership by the end of World War II. Despite their poor finances, however, the
transit lines still provided valuable mobility and accessibility for Chicago, and the voters responded by approving municipalization. The Chicago Transit Authority was formed in 1947 by the combination of the CRT and the CSL, and the Chicago Motor Coach Company (a still-profitable bus operation that focused mainly on lakeshore routes) was added in 1952.

The CTA undertook a sizable "modernization program" in the 1950s and 60s (see Garfield at www.chicago-l.org for an excellent summary). Railcars were upgraded, electric streetcars were replaced with buses (reducing the required investment in right-of-way), underused elevated railways were closed, and new transit tracks were laid in the medians of the city's expressways. Despite these investments, however, transit continued to falter, as the city lost population to the suburbs and the CTA, especially on its bus routes, lost riders to the automobile.

2.2.3.2 The Role Of The Streets

Some of the decline in mass transit's share of the ground transportation market was unavoidable, and even desirable. The private auto was able to provide accessibility to an expanding city and region in a way that mass transit could not match, even if not beset by financial or political troubles. Another portion of the decline can be attributed to zoning decisions and government subsidies for single-family home mortgages. Yet the dominance of the auto came to be nearly overwhelming, and that outcome stems in part from explicit transportation policy decisions regarding roads and their appropriate uses.

According to Barrett, the crucial decision (reiterated over time through court decisions) was that no class of privately owned vehicles could have priority on city streets, thus foreclosing the possibility of traffic segregation. Although private streetcars had the legal right-of-way on their tracks, the Illinois Supreme Court ruled that the public had the right to use the entire street, and in practice the streetcars were forced to accommodate other traffic. Teamster wagons were particularly egregious users of the streetcar tracks, and the streetcars had little immediate recourse. Eventually, a combination of traffic enforcement by mounted police officers and agreements with major teamster organizations served to somewhat separate the wagons and the streetcars. By that time, however, automobiles were making streetcar travel even more difficult, and similar intervention was much more difficult.

Yet the policy of rejecting segregation of the public space was not applied equally. Three distinct examples make this inequality clear:

A. The increasing speed of automobiles presented a danger to pedestrians who often shared the road with the streetcars and wagons during crowded times of day. Limiting
the speed of automobiles was both politically touchy and difficult to implement, though, so the automobile was accommodated. Segregation of the public space was allowed, and pedestrian travel was definitively limited to sidewalks and crosswalks.

B. *De facto* segregation of the road network was permitted with regard to parking. Enforcement of the thirty-minute parking limit during the midday in the Loop was poor, and double-parking was common, which forced automobiles into conflicts with streetcars. Small businesses tended to favor on-street parking, while many large downtown businesses (with the support of the Chicago Association of Commerce) backed a downtown parking ban to improve traffic flow. Yet this ban was not the accommodation to pedestrians, transit, or freight that it might appear to be, for they also pushed for municipally owned or non-profit garages to handle the increasing parking demand. Ultimately, conflicting pressures prevented action, and on-street parking in the Loop remained. Moreover, on-street parking became ubiquitous outside of the downtown area, securing a vast chunk of public road space for a particular class of vehicles.

C. Explicit traffic segregation was allowed on the boulevards of Chicago. These broad and landscaped roads ringed the city and were closed to wagon, truck, and transit traffic (though some buses were later allowed on them). The boulevards were under the control of the Park District and were well funded by the city in post-Burnham Chicago, and they made automobile travel increasingly attractive. With their higher speeds and limited access, they also offered a vision of even larger roads that would soon appear in Chicago, financed by state and federal dollars.

As automobile and truck traffic continued to grow in the 1920s and 30s, the need for better regional connectivity became apparent, and a nationwide network of expressways was planned by Roosevelt in 1939. This became the basis for the Federal-Aid Highway Act of 1956, which created the framework for constructing our 44,000-mile Interstate Highway system. The key feature was the pay-as-you-go Trust Fund that offered 90% federal funding for building toll-free highway links if states would fund the remaining 10% (see Weingrof).

Although the highways were originally intended to connect and bypass cities, the 1960s and early 70s saw a number of interstate highways constructed directly in the urban cores of major cities, and Chicago was no exception. During the mayoralty of Richard J. Daley, all of the major expressways radiating from downtown Chicago (the Eisenhower, Kennedy, Stevenson, and
Dan Ryan) were either completed or initiated. The Dan Ryan Expressway, heading south out of
downtown, was especially notable, with seven lanes of traffic in each direction. These urban
freeways have been widely criticized (see Cohen & Taylor, for example) for encouraging flight
to the suburbs, destroying existing neighborhoods, and reinforcing racial segregation in the city.
And despite their potential economic benefits, they have also become very congested, which
threatens the economic health of the city on multiple dimensions.

2.2.3.3 Trucking And Intermodalism

The construction of the interstate system was a particular boon to the trucking sector. As
the shipping of raw materials became less important to the economy, the production and
distribution of smaller manufactured goods took prominence. The flexibility and cost structure
of trucking made it an attractive alternative to the railroads for these types of products and
allowed truck carriers to be more competitive and customer-oriented. Road quality and
capacity were trucking’s only serious impediments, and the interstate highway system solved
this problem. According to the Census Commodity Flow Survey, single-mode trucking alone
now handles over 70% of the goods shipped in the U.S. when measured by value.7

Yet freight rail service, unlike its passenger counterpart, is still a significant part of the
nationwide transportation network. The more recent growth in intermodal traffic has also
proved to be a boon to Chicago, which has become the nation’s hub for intermodal shipping.
The Chicago Area Transportation Study (CATS) estimated that the freight industry employed
over 114,000 workers from northeastern Illinois in 1996.8 Yet there is a cost that comes with this
activity. As noted above, many of the loads need to be transferred from yard to yard, and
studies (e.g., Li et al., 2001) have found that over 15,000 daily truck trips are created from these
movements. These trucks both create and are impaired by roadway congestion, and continued
congestion threatens the growth of this important industry.

2.3 The Current Crisis for the CTA

Chicago has rebounded from its worst years of job and population loss. The goal for the city
now is continued growth, and a robust transportation system is a key to drawing residents and

7 If measured by tons or ton-miles, the share for trucking is lower, since rail tends to carry heavier,
commodity-type freight over longer distances (e.g., coal).
8 As quoted by the Center For Neighborhood Technology (www.cnt.org), 2002.
businesses. But the surface transportation network that provides such economic and social advantages to the city faces an uncertain future.

2.3.1.1 Can Transit Grow?

Despite its difficulties, transit still plays an important role in providing accessibility to people living and working in Chicago. The 2000 Census found that more than 20% of workers in the central county (Cook) use transit as their primary means of transportation to work, and in the Chicago MSA the share is 11.5%, second only to New York. Perhaps more significantly, over the five years from 1997 to 2002, the Chicago Transit Authority reversed trend and experienced a minor resurgence in ridership, after decades of decline. Since 1997, total system ridership (in unlinked trips) has increased 7.5%, although growth has recently stagnated along with the national economic slowdown.

At the same time, the state and federal governments have shown an increased willingness to make capital investments in rehabilitating the transit infrastructure. The Illinois FIRST program, which funds transportation, education, and general infrastructure projects across the state, agreed in 2001 to match funds with the federal New Start program to fund a $482 million renovation of the Douglas branch of the Blue Line on Chicago’s West Side. Without the renovation, that entire elevated section would likely have been completely closed within a few years. At the same time, the CTA’s proposal for modernization and expansion of stations on the Brown Line has also received federal New Start funding, and work has already begun on changes that will add much-needed capacity to that line.

Yet many concerns remain. Just as during the heyday of the streetcar decades ago, the majority of transit passengers in Chicago are carried by buses on the ground rather than on rail rapid transit. Approximately two-thirds of CTA trips are bus passengers, yet the growth described above has come mostly from increases in rail transit usage. As gentrification revived some North and West Side neighborhoods, the ridership on the Brown Line (up almost 9% in 2001 over 2000) and the Green Line (up 7%) grew, and the other lines have increased as well. At the same time, bus patronage has been stagnating or even declining. Looking forward, the CTA continues to foresee modest growth on the rail side, which may exacerbate the peak-hour congestion experienced on some lines. But despite a number of planned efforts for the bus network, including schedule improvements and vehicle overhauls, the forecast ridership for 2004 is below that of 2002, in part because of a fare increase.
The current governance and funding structures for public transportation in Chicago are also a concern. The Regional Transportation Authority (RTA) was created by the General Assembly in 1974 as the public body responsible for oversight of the CTA and also the suburban bus (Pace) and commuter rail (Metra) systems. The most recent major changes to the RTA legislation occurred more than twenty years ago (1983). Each of the three service boards operates independently, but the RTA board has approval power over annual budgets, and almost all public funding is channeled through the RTA. And while there is some political concern over the makeup of the RTA board, the economic concerns relate to the funding structures and budgetary constraints mandated by the RTA.

Operating subsidies for CTA, Pace, and Metra derive predominately from a region-wide sales tax - 1% in Cook County and 1/4% in the collar counties. 85% of the funds collected from this tax are allocated to the service boards strictly by geographical formula. The economic and population growth in the suburbs has been much stronger than that in Chicago, and the sales tax revenue growth in Chicago has trailed inflation. With the elimination of federal operating support in the mid-1990s and the increasing and unfunded financial burden of paratransit, the RTA has been forced to allocate nearly all of its annual discretionary funding to the CTA simply to keep it operational. In fact, had funding levels since 1985 kept pace with inflation, the CTA would receive $90 million more for operations in 2004. Because of this structure, Metra has been “fully funded” by the RTA, and Metra ridership actually increased over the entire 1983-2003 period. Yet this result is somewhat perverse, since the average Metra trip is much more highly subsidized than the average CTA trip. In suburban Cook County, for example, where both CTA and Metra operate, the estimated subsidy per trip is $1.45 for CTA but $2.47 for Metra.9

The other obstacle is the RTA-mandated recovery ratio, which requires that the three service boards combined must recover at least 50% of their operating costs from the farebox and other revenue sources such as advertising. (There are some minor exceptions and allowances.) While the goal of enforcing cost-efficiency is well-intentioned, this mandate is strict compared to the rest of the U.S. public transit industry and can induce perverse outcomes. When economic conditions worsen and ridership stagnates or drops independently of agency performance (as has happened very recently), the recovery ratio can force the agency into cutting service or increasing fares at precisely the wrong time, potentially starting a vicious downward cycle.

9 Internal analysis by Jason Lee, Chicago Transit Authority, April 2004.
2.3.2 Will Trucks Move?

The 15,000 daily intermodal truck movements mentioned above are projected to quadruple within the next two decades. Chicago and its surrounding governments clearly must be concerned about the congestion and potential safety hazards that may arise as these trucks traverse local and arterial streets before they enter yards or access an interstate highway. At the same time, however, if Chicago is to maintain its position as the premier inland port in the U.S., it must find ways to accommodate these transfers and ensure that they remain efficient.

In their 2001 paper, for example, Li et al. find that approximately two-thirds of the daily container movements are local or cross-town, meaning that they rely heavily on non-interstate roadways. While the roadways directly adjacent to the yards have often been improved, the city intersections are often incompatible with large and even medium sized container trucks. Long delays and safety hazards can occur in these situations (and become more problematic as congestion increases), and the higher volume of pedestrians on the multi-use city streets poses an additional concern. Yet despite the existence of an Intermodal Advisory Task Force, there have been few concrete steps taken by the city to address this issue.

2.4 Conclusion: Evaluating Possible Changes

If street-based transportation is to continue to serve as a facilitator of Chicago’s growth, consideration must be given to improving its operational capability and capacity when planning the transportation network of the coming years. In the next chapter, we review methods for assessing and evaluating public transit, with an eye toward building a model that can assist in evaluating the costs and benefits of changing public subsidies for transit.
3 Framework: Transit Assessment and Evaluation

As outlined above, transit ridership has declined significantly in the postwar period, with the intermittent periods of modest growth (including the recent mid-to-late 1990s increase) unable to reverse a continuing trend of falling market share. The losses can be attributed both to natural shifting to a competing mode which is superior for many types of trips and to constraints (both explicit and implicit) which prevented transit from providing its services optimally. Yet we cannot judge transit as a success or failure on ridership and market share alone. More importantly, in order to assess the impacts of proposed changes to public transit provision, we require a more comprehensive framework for decision-making. In this chapter, we review available methodologies for evaluating transit investments.

3.1 Measuring Outcomes in the Absence of Profit

For firms in the private sector that receive no public subsidies, we generally make the assumption that the ultimate objective of the firm is profit maximization. This requires an abstraction from reality – it ignores, for example, the potential for agency problems between the managers of the firm and its shareholders, and also the possibility that some firms have other non-monetary goals for which they sacrifice profit. But overall, profit maximization subject to budget constraints is a reasonable assumption for modeling firm behavior, and in a competitive market without externalities (again, a strong assumption, and one which can often be violated) this behavior also leads to social welfare maximization. Thus, we can reasonably evaluate and compare long-run firm performance based on profit and profit-related measures (e.g., return on assets).

For entities in the public sector, the task of performance evaluation is less clear. When part or all of the costs of an agency are supported by revenues which are independent of the agency’s actions, the simple “profit-maximization-within-budget-constraint” framework is not applicable, and the universe of possible behavioral goals for the agency grows considerably. This issue is especially acute for public transit, which is not a classic public service like firefighting or national defense which covers all citizens and does not “charge” for its services. Instead, transit must target specific customers, determine appropriate fare levels, and constantly manage service quality and availability, while at the same time receiving tax-financed public funding from unrelated sources (e.g., sales taxes).
In the postwar period, where transit has received subsidies from many levels of government, a number of different possible managerial objectives have been identified. An agency could plausibly act so as to: maximize total ridership; maximize service provision (e.g., vehicle miles); maximize total societal welfare; minimize fares; minimize required public subsidy; or even maximize some "political" objective, such as wages to particular classes of transit workers. The agency may be trying to achieve multiple goals at once, and the objectives may shift over time as the political environment changes. For example, in his analysis of management objectives at the Chicago Transit Authority, Savage (2002) finds evidence that the CTA appears for the most part to have followed a strategy of maximizing service output subject to a budget constraint of varying firmness (depending on the political situation). This, in turn, implies management attempts to achieve unit cost minimization (allowing more service production) and relatively high fares. He posits that during the mid-1970s, however, the large increase in available subsidies effectively removed the budget constraint, and management objectives shifted to lower fares and to increased compensation for labor. A more pessimistic (but not necessarily incorrect) proposition is that most transit managers currently face so many financial and political constraints that they seek to satisfice rather than optimize their service provision. That is, simply maintaining the previous year's level of service, with minor improvements if possible, may be an acceptable objective.

Thus, given the potential competing objectives of transit service providers, it seems unlikely that we can identify a single measure with which to evaluate public transit. Instead, we will examine a collection of indicators. First, we review internal indicators of performance, concentrating on the dimensions of efficiency and effectiveness. These measures are useful for comparing transit performance across time and across peer agencies, and will serve as key points of sensitivity when constructing models to evaluate the efficacy of buying back transit trips. Next, we review external measures of the benefits generated by transit. It is these benefits which must ultimately be the source of our willingness to subsidize public transit. Finally, we give a brief review of cost-benefit analysis, which will allow us to tie together the various strands of investigation into a coherent framework.

3.2 Internal Assessment: Performance Evaluation

Academic and professional interest in transit performance evaluation in the U.S. began in earnest in the 1970s. During this period, state and local governments were searching for improved methodologies to monitor their newly-municipalized transit services. At the same
time, the federal government was increasing the subsidies it was making available to public transit providers and wanted a framework with which to evaluate the effects of those subsidies. These two needs, combined with falling ridership and a general dissatisfaction over the perceived performance of transit, led to significant research in this area.

3.2.1 Efficiency and Effectiveness

The seminal studies in performance evaluation – by Dajani and Gilbert and by Fielding, among many others – make clear that performance evaluation for a public sector enterprise must include indicators of both efficiency and effectiveness. An efficiency measure will gauge the level of resources required by the transit provider to produce a given level of service output, while an effectiveness measure will indicate the intensity of usage of the transit system by riders, relative to the amount of service provided. Figure 3-1 outlines the basic relationships among the inputs and outputs of transit provision.

![Figure 3-1: Transit Performance Analysis](image)

This approach provides a useful framework for the transit analyst. When considering only the production of transit, we can examine measures of cost-efficiency that relate the expenditure of valuable input resources to the output of transit services. A measure such as 'total operating expense per revenue vehicle hour' would fall into this category, though any number of similar indicators can be created. Such a measure can be useful for examining the productive efficiency of an agency and, when broken down into more discrete measures (such as vehicle hours per
employee), it can provide guidance for cost reductions. These measures give no information, however, about the attractiveness of the service that is created for the potential riders.

Indicators of service-effectiveness (the bottom leg of the Figure 3-1 triangle), which relate service consumed to service provided, can offer guidance on the relevance and quality of the transit service. A measure such as ‘passenger miles per revenue vehicle mile’ indicates to the agency how intensively the services it provides are being used by passengers, and comparisons across routes and times of day can be very instructive. Again, though, such measures cannot provide the whole picture, as they ignore the cost of providing a given level of service.

Many researchers advocate judging overall transit performance by measures of cost-effectiveness, as shown on the third leg of the triangle. In this view, the ultimate objective of the transit agency is the generation of ridership, with vehicle miles and hours as simply intermediate products in that process. In this view, then, the relevant indicators are ratios such as ‘passenger trips per dollar of operating expense’ that express service consumption in terms of input costs. Such an approach can be extended yet another step to incorporate the effects of fare policy. If total farebox revenue (or, more generally, operating revenue) is removed from total operating expense, then an indicator such as ‘deficit per passenger trip’ is available, which describes the public subsidy required to generate a transit trip.

‘Subsidy per trip’ might appear at first to be a “holy grail” for transit evaluation, one that could be used in place of market-based measures to compare performance across different agencies and evaluate the suitability of further public funds to “buy” more transit trips for a region. Yet despite the usefulness of the measure, such a hope is misplaced, for a number of important reasons. First, the measure describes only the average transit trip on a system or route, and contains very little information about the marginal cost of attracting new trips. Second, such a gross measure offers little practical advice for targeting investments. Though vehicle miles may be an intermediate good in the transit production process, the agency must ultimately make its decisions on the basis of how and where to operate its vehicles. Moreover, distributional issues—such as the inherent risk aversion that results from the political reality that service cuts are more strongly perceived than service gains—may be stronger decision factor than such “objective” performance measures. Third, even if we assume transit providers are operating under identical optimization frameworks (a strong assumption), there can be substantial differences in the constraints facing the agencies. System size, peak-to-base ratio, average operating speed, population density, job location patterns, and many other exogenous
and semi-exogenous factors can strongly influence the level of productivity available to a transit provider and the attractiveness of transit to potential riders. In creating our model, we must consider which factors are generic to transit as an industry and which are specific to Chicago and other metropolitan areas.

3.2.2 Recent Performance Trends

Performance data on U.S. public transit is available through the National Transit Database (NTD), an outgrowth of Section 15 of the Urban Mass Transportation Act. The federal government requires that transit agencies report a wide range of data on ridership, expenditures, and service provision across a number of modal and operational categories. These reports are compiled annually into the NTD, which serves as a very useful (though not flawless) source for performance evaluation.

We briefly present three performance indicators (as shown in Table 3-1) for motorbus service provided by the Chicago Transit Authority and three other large transit agencies – those in Boston, Houston, and Washington, DC – during the period 1996-2002. These three agencies are useful comparisons because they are roughly similar in size to the CTA, and yet they exist in diverse operational settings. The MBTA in Boston is one of the nation’s oldest transit systems, and much of Boston’s initial development grew up around transit lines. WMATA in Washington, DC, is a product of the surge in transit infrastructure investment in the 1960s and 70s and has become increasingly popular in the growing metropolitan DC area. METRO in Houston has just introduced its first light rail line in 2004, and serves a more automobile-focused and low-density population.

As noted above, a wide range of indicators can be created from basic data on costs, output, and ridership. Most of these indicators have a high degree of collinearity, however, and represent similar underlying processes. Because of this, a small set of indicators can provide a large amount of information. In addition, while performance comparisons across agencies can be useful, we avoid drawing conclusions from any differences at this stage. City-specific exogenous factors may have a strong influence on performance, and differences in cost-allocation methodologies may skew cross-agency results.
### Table 3-1: Performance Indicators

<table>
<thead>
<tr>
<th>PERFORMANCE DIMENSION</th>
<th>SELECTED INDICATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Efficiency</td>
<td>Operating Expense per Vehicle Revenue Hour</td>
</tr>
<tr>
<td>Service Effectiveness</td>
<td>Passengers per Vehicle Revenue Mile</td>
</tr>
<tr>
<td>Cost Effectiveness</td>
<td>Operating Expense per Passenger Trip (Unlinked)</td>
</tr>
</tbody>
</table>

#### 3.2.2.1 Agency Bus Characteristics in 2002

Table 3-2 presents basic descriptors for the bus operations in Chicago and the three peer agencies, in order to make later comparisons more meaningful. By all measures, Chicago is the largest of the four agencies. Boston and Houston are comparable in expenditures and passengers, though the MBTA has a much higher intensity of usage for the level of service it provides. Washington, DC, operates a similar number of vehicles and bus hours to Houston, but carries more passengers and faces a slightly higher peak-to-base ratio.

#### Table 3-2: Bus Operating Statistics (2002)

<table>
<thead>
<tr>
<th>Bus Operating Statistics</th>
<th>City (Agency)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boston (MBTA)</td>
</tr>
<tr>
<td>Operating Expenses (000)</td>
<td>$238,566</td>
</tr>
<tr>
<td>Passengers (000)</td>
<td>108,692</td>
</tr>
<tr>
<td>Vehicle Revenue Hours (000)</td>
<td>2,451</td>
</tr>
<tr>
<td>Vehicles Operating in Maximum Service</td>
<td>863</td>
</tr>
<tr>
<td>Peak-to-Base Ratio</td>
<td>2.50</td>
</tr>
</tbody>
</table>

#### 3.2.2.2 Cost Efficiency

The years from 1996 to 2002 were generally good ones for ridership in U.S. transit agencies, as noted above. However, there was little progress made in improving bus cost efficiency in the four agencies considered here. Figure 3-2 details the trends in real operating costs per revenue vehicle hour during the period, with 1996 taken as the base year. All four agencies were essentially flat over the period, with changes of only ±5% over six years. (The 2001 data point for Houston is questionable.) This may be an indication that the fixed-proportions nature of bus service production, where each vehicle-hour requires exactly one driver-hour, is difficult to significantly alter. But it should also raise concerns when considering the sensitivity of a model to cost-efficiency changes - such changes may be very difficult to achieve.
3.2.2.3 Service Effectiveness

Figure 3-3 shows the trends across the same period in service effectiveness for the four agencies. This measure of trips per revenue vehicle mile is one indicator of patronage intensity or load factor. Again, the trends are not necessarily encouraging for these agencies. Chicago and Houston remained essentially flat across the period, although both peaked at slightly higher levels during 1999 and have since come down. Washington, DC, has shown a modest increase during the period (roughly 8%), while Boston has trended downward, reducing its service effectiveness by approximately 8%. All four of the agencies were adding revenue miles to their networks during this period.
Service Effectiveness:
Unlinked Passenger Trips/Revenue Vehicle Mile

![Graph showing service effectiveness trends across years for Boston (MBTA), Chicago (CTA), Houston (METRO), and Washington, DC (WMATA).](image)

**Figure 3-3: Service Effectiveness Trends**

### 3.2.2.4 Cost Effectiveness

Finally, Figure 3-4 shows the agency trends in *cost effectiveness* over the 1996-2002 period as measured by total real operating cost per unlinked passenger trip, again with 1996 as the base year. The performance here was similar to that for service effectiveness. Chicago and Houston were roughly flat across the period (though again Houston’s recent volatility is cause for some concern regarding the data), while Boston’s cost per trip exceeded inflation by more than 12% during the period. At the same time, nominal expenses per bus trip in Washington, DC, were essentially flat, meaning that real costs fell by approximately 12%.

This final chart also clearly displays why cost-effectiveness is the key dimension from a large-scale policy-making perspective. Consider the performance indicators for METRO in Houston, a heavily auto-dependent area not often considered conducive to public transit investments. If only service effectiveness is used to judge performance, then Houston certainly lags compared to other large cities. Yet cost-effectiveness indicators show that providing bus service in Houston is markedly cheaper than in other cities. If we combine these and look at cost-effectiveness, we see that bus service in Houston is essentially as effective as that in Washington, DC, and that the gap has been closing relative to the other agencies. We should not write off potential investments in cities such as Houston simply because they do not compare in intensity of usage with older, more transit-dependent cities.
3.3 External Assessment: Benefits of Public Transit

The framework described above for assessing the efficiency and effectiveness of a transit provider has been valuable for the transit industry and those charged with monitoring it. Yet that framework is too narrow to address questions about the larger economic and social value of public transit investment, for it selects ‘passenger trips’ as the objective of interest and goes no further. Moreover, it implicitly assumes an ‘optimization’ approach by transit managers that, given the strong constraints under which they operate, may simply not be the case. To answer such larger questions, we must specifically examine what value derives from the investments and expenditures that create those passenger trips.

3.3.1 Macroeconomic Growth

Before turning to disaggregate measures of value, we consider the possibility that public transit has a significant positive effect on overall economic growth. During the early 1990s, a significant academic effort was focused on determining the relationship, if any, between public sector capital investment and private sector productivity and output. Public transit clearly falls under this umbrella, along with other public sector capital investments such as highways, water, and sewers. An unambiguously positive linkage between public investment and growth
would bolster transit supporters and perhaps eliminate the view among many that transit is simply a social service of little overall value.

This research effort was spurred by Aschauer in 1989, who found a surprisingly large economic impact from public investment. Using national level data, he estimated an elasticity of private output with respect to public capital of 0.39, a value higher than the elasticity with respect to private capital. These findings were supported by some researchers, such as Munnell (1990), but were soon disputed by many others, including Garcia-Mila and McGuire (1992) and Holtz-Eakin (1994). These researchers, using state-level data, found a negligible spillover effect from public investment when the econometric framework was altered to account for state-specific factors. The ambiguous findings of Morrison and Schwartz (1996), who took a narrower view and considered the effects of infrastructure investments on manufacturing firms, are also typical. They found that infrastructure investment had a positive effect on firm productivity, but that the net social benefits could be positive or negative depending on the costs of raising the funds and the overall growth rate of output in the economy.

Further study of the macroeconomic impact of public investment has languished recently, as researchers have been unable to solve the complex econometric issues that have confounded model estimation. A number of rival hypotheses remain potentially valid: that public investment causes economic growth, possibly with a time lag and possibly with a further multiplier effect; that economic growth spurs governments to undertake public investment; that public investment is undertaken on the expectation of future growth; that multiplier effects from capital investment are being captured; or that growth and public investment are essentially unrelated. However, this open research question does not imply that public capital may provide no benefits. As Holtz-Eakin writes regarding his finding of a zero elasticity of private output with respect to state and local capital:

It would be wrong to conclude from this analysis that the large stock of public capital provides no benefits. The regression analysis indicates only that the productivity benefits in excess of direct provision of amenities are negligible. It would be a departure of common sense to argue that there are not important direct effects from the provision of road networks, bridge, water supply systems, sewerage facilities, and the host of other infrastructure services. Similarly, there are presumably a wide array of capital expenditure projects that would survive a rigorous benefit-cost examination. Instead, the main message is that the use of aggregate data does not reveal sufficiently large linkages between public sector capital and private production activities to support the contention
that government capital spillovers are the source of economy-wide variations in private productivity. [emphasis added]

Although Holtz-Eakin is writing only of capital investments, we believe his comments are applicable to public transportation, which requires a mix of both capital investment (vehicles, right-of-way, etc.) and simple expenditures (labor, fuel, etc.). With this in mind, we now consider those "direct effects" of public transportation investment and expenditure through a cost-benefit framework.

3.3.2 Cost-Benefit Analysis

The underlying principle behind cost-benefit analysis as a tool for transit evaluation is simple. If the aim of public policy is to maximize net social welfare subject to financial and political feasibility constraints, then a methodology is needed to consistently evaluate the welfare changes from various potential projects. Yet large public investments generally involve monopoly provision, significant changes in output, and indirect benefits distributed across disparate groups (Meyer and Straszheim). For these reasons, it is very difficult to obtain the price signals one usually uses as a guide to investment. Cost-benefit analysis has evolved as a tool for indirectly creating such signals. If the costs and benefits of various projects can be translated into a common unit (usually dollars), then the projects can be evaluated according to the net stream of benefits they produce over a given period, and prioritization is a matter of choosing those projects which provide the best return.

In practice, of course, this translation can be very difficult. The value of intangible benefits (e.g., pollution reduction) is difficult to estimate. Benefits may be transferred among different constituencies. The proper discounting of future costs and benefits can be especially controversial, as some have even questioned the propriety of using cost-benefit analysis at all when environmental or inter-generational questions are being considered. Yet if the analysis process is transparent, with assumptions open to criticism and results used to inform a larger political process, then there is widespread agreement that cost-benefit analysis is a very useful tool (Small, 1999).

3.3.2.1 Basic Principles and Problems

Although many methods exist for measuring the social gain associated with a project, net present value (NPV) is the preferred methodology for the estimation of costs and benefits across

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10 See, for example, Heinzerling and Ackerman, "Pricing the Priceless."
time. Many extended treatments of the NPV approach exist, so only key points are noted here. Figure 3-5 below shows a stylized chart of the required steps for determining the NPV of a project. A number of complicated issues, both theoretical and practical, appear immediately in this brief diagram.

<table>
<thead>
<tr>
<th>Determine the time horizon under consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate project costs in each future period</td>
</tr>
<tr>
<td>Translate any non-monetary costs into dollar figures</td>
</tr>
<tr>
<td>Estimate gross project benefits in each future period</td>
</tr>
<tr>
<td>Translate any non-monetary gross benefits into dollar figures</td>
</tr>
<tr>
<td>Determine the net benefit (gross benefit - cost) in each period</td>
</tr>
<tr>
<td>Determine the appropriate market discount rate for the project</td>
</tr>
<tr>
<td>Discount the net benefit in each period back to the present</td>
</tr>
<tr>
<td>Sum all discounted net benefits to determine the project NPV</td>
</tr>
</tbody>
</table>

**Figure 3-5: Theoretical NPV Calculation**

Determining the appropriate time frame for analysis is perhaps of less concern, as the expected usable life of the facility offers some guidance. Likewise, the determination of monetary project costs is a surmountable problem, although both genuine uncertainty and the biases of project evaluators can cause strong divergence between predicted and actual costs, as researchers such as Pickrell have demonstrated. Finally, there are pitfalls involved in measuring benefits since the benefits can be transferred. In the classic example, a rise in land values following a transportation improvement in a corridor represents a transfer to land owners of some of the benefits (usually time savings) initially conferred on the travelers. Improvements in understanding and modeling technique, however, have mitigated much of this double-counting.

The difficulty in assigning monetary values to the non-monetary costs and benefits of a project is of greater concern. The standard approach is to calculate some measure of "willingness-to-pay" for the benefit or cost. To judge the benefit of an improvement in safety, for example, analysts will often use the wage differential between similar jobs with different risks of injury or death as a proxy. Even this approach is difficult for benefits like dispersed
environmental improvements (such as a reduction in carbon dioxide emissions), and analysts have had difficulty incorporating such improvements into their models consistently.

The choice of an appropriate interest rate for discounting is also challenging. Using market rates requires two assumptions: that the market in which the project exists is “perfect,” and that income maximization is the criterion for project evaluation. Most markets are demonstrably “imperfect” in the economic sense – borrowing and lending may not be possible at the same rates, full information is often not available, and some actors may have market power. Yet in more developed countries such as the U.S., these imperfections are generally not deemed fatal. Meyer and Straszheim claim that in such cases, highly-rated long-term corporate debt is reasonable as a cost-of-capital estimate for the public sector, since it measures the private investment displaced by bonding or taxing. The question of the proper maximization criterion is less clear. Many have advocated that a lower “social” discount rate, which explicitly increases the value placed on costs and benefits borne by future persons, should be used.

The obvious “social” aspect of public investment is the foundation of the most common criticism of cost-benefit analysis. By its nature, an NPV calculation cannot determine the distributional effects of a project across society, and these effects are clearly important for the political process in which project evaluation occurs. But cost-benefit analysis does perform an important function by identifying projects that are potential Pareto improvements. That is, it finds projects where benefits outweigh costs such that “winners” could compensate “losers” and leave all parties better off. Thus, as long as cost-benefit analysis is used as part of a process that also identifies and addresses distributional effects, its use as a decision-making tool is appropriate.

3.3.2.2 Related Measures

Two concepts that are closely related to NPV are also of interest: the benefit-cost ratio (BCR) and the internal rate of return (IRR). To calculate the BCR of a project, gross benefits and costs are tallied separately and then discounted. The BCR is then simply the ratio of discounted gross benefits to discounted costs. For a given discount rate, NPV and BCR will give the same signal about basic project attractiveness (i.e., a positive NPV or a BCR greater than unity), but they may produce different rankings of the “best” projects. When budgetary constraints are in effect, these potential differences should be considered.

The IRR provides a slightly different perspective than the NPV, but it must be used cautiously. The calculation essentially proceeds in reverse – the IRR is the discount rate at
which the NPV of the stream of costs and benefits of a project is zero. Projects can then be ranked according to their IRRs, and the decision rule in a situation with unconstrained budgets would be to approve any project with an IRR greater than the relevant cost-of-capital (again, not always an obvious figure). A "return on investment" measure such as IRR has great appeal to analysts and decision-makers, since it translates complex projects into the language of standard financial instruments.

However, Brealey and Myers, among others, have cautioned against using IRR as a decision tool. In extreme cases, multiple IRRs (which are simply roots of the NPV function) can be found. However, in most investments where costs are incurred up front and benefits are reaped in the future, this proves to not be an issue. Of more concern is the potential conflict between NPV and IRR in cases of mutually exclusive investments, as is often the case in transportation. An IRR calculation assumes that project benefits are reinvested at the IRR, while an NPV calculation assumes they are reinvested at the discount rate. In this case, a strict IRR decision rule could lead to misallocation of resources. In response to this critique, many analysts perform modified internal rate of return (MIRR) calculations that assume reinvestment at the relevant cost-of-capital. For transportation projects, this appears to be especially appropriate.

3.3.2.3 Practical Implications

The use of cost-benefit analysis across agencies and levels of government varies widely. In some cases, cost-benefit analysis can be mandated and used as a primary regulatory tool (such as in the Safe Drinking Water Act\textsuperscript{11}), while other statutes (such as the Clean Air Act) require that public health and technological feasibility must be the guiding principles. In order to ground later analyses in the relevant environment, some of the key legislation and regulation that governs transportation investment decision-making is outlined below.

3.3.2.3.1 Office of Management and Budget (OMB)

The OMB last updated its Circular A-94 ("Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits") in 1992. The circular mandates that cost-benefit analyses of investments and regulations should report NPV and related measures based on a real discount rate of 7%, although it encourages calculating sensitivity measures and allows other discount

\footnote{See, for example, "Understanding the Safe Drinking Water Act," U.S. Environmental Protection Agency, 1999.}
rates in limited circumstances. Two other sections of the circular deserve consideration when the question of improving practice is addressed. First, the circular’s ‘Purpose’ states that “the goal of [the] Circular is to promote efficient resource allocation through well-informed decision-making by the Federal Government.” Second, the circular addresses the question of using IRR measures:

Analyses may include among the reported outcomes the internal rate of return implied by the stream of benefits and costs. ... While the internal rate of return does not generally provide an acceptable decision criterion, it does provide useful information, particularly when budgets are constrained or there is uncertainty about the appropriate discount rate [emphasis added].

3.3.2.3.2 Federal Transit Administration (FTA)

A review of the FTA New Start program is instructive regarding the implementation of cost-benefit analysis. TEA-21 outlines the project evaluation procedures for federal transit investments under the New Start program. The procedures are closely tied to environmental impact requirements in NEPA. After a corridor has been identified as having mobility needs, an alternatives analysis must be undertaken. This analysis, which requires preliminary engineering, is meant as an initial public evaluation of all reasonable potential actions, including a “no action” option. Projects that survive the alternatives analysis undergo a more detailed evaluation on a number of dimensions, including:

- Direct and indirect costs
- Congestion relief
- Improved mobility
- Air and noise pollution
- Energy consumption
- Associated ancillary and mitigation costs
- Reductions in local infrastructure costs

Finally, the projects are evaluated on the quality of the local financing. Reliability, evidence of contingency planning, and the ability to continue operating the existing system at an acceptable level are expected. After this three-step process, projects are rated as ‘highly recommended,’ ‘recommended,’ or ‘not recommended.’ 12,13 The Blue Line reconstruction for the Chicago Transit

12 "Transportation Equity Act for the 21st Century" (Public Law 105-178), Sec 3009.
Authority, for example, only achieved its 'highly recommended' status after the Illinois FIRST program provided significant and steady local financing.

Based on this description, it would seem that cost-benefit analysis would be a primary tool in FTA project evaluation. This is not the case. Many of the elements of cost-benefit analysis are present (though disparate rather than unified), yet there is an apparent unwillingness to commit to the kind of priority-setting that cost-benefit analysis might imply. While a measure of caution would of course be appropriate in attempting to value project benefits, for the reasons outlined above, TEA-21 went significantly further and expressly prohibited the consideration of the dollar value of mobility improvements. While such a prohibition appears to increase the flexibility of decision-makers when considering projects, it may also serve to obscure important aspects of the project's risk and return. This apparently sub-optimal process is a reflection of the "lumpiness" of transit investments and jurisdictional conflicts that often occur during the political process.

3.3.2.3.3 Federal Highway Administration (FHWA)

With the completion of the Interstate system, the focus of FHWA investment has shifted to maintenance, rehabilitation, and pollution and congestion mitigation. Again, the use of cost-benefit analysis appears to be inconsistent. When informally analyzing the impact of highway improvements on freight and logistics organizations, for example, FHWA is willing to explicitly discuss cost-benefit analysis, methodologies for improving benefit estimation, and strategies for dealing with both competitive and monopolized markets.\textsuperscript{14} The Highway Economic Requirements System (HERS), which was recently developed, also provides explicit cost-benefit rankings of potential improvements to deficient highway sections.\textsuperscript{15} Yet when a study of the Congestion Mitigation and Air Quality (CMAQ) program was authorized by TEA-21, only a mandate to assess the cost-effectiveness of mitigation projects was included. While clearly not without value, this analysis simply ranks projects based on minimum cost for achieving a given mitigation level, and it says nothing about an appropriate level. Again, an opportunity for more sophisticated analysis is potentially being missed.


3.3.2.3.4 State of Illinois

Transportation improvement in Illinois is guided in part by the Illinois Capital Budget Act and the Illinois Highway Code. The methodologies for project evaluation included in these acts are quite vague, and probably intentionally so. The Capital Budget Act requires that five-year capital budget programs be prepared that include “economic assumptions, engineering standards, estimates of spending for operations and maintenance, federal and State regulations, and estimation of demand for services.” The Highway Code, describing planning and programming at the state level, merely authorizes IDOT to determine the “reasonably anticipated future need” for highway investments by making traffic surveys, studying facilities, and collecting and reviewing data that affects “judicious planning.”

However, IDOT will use cost-benefit analysis in limited situations. The state’s Rail Freight Program (RFP), for example, offers grants and low interest loans for rail improvements that will foster economic development. The evaluation of projects depends on a benefit/cost ratio, and benefits such as job creation and retention are expected to be explicitly described. As at the federal level, there appears to inconsistency in the application of rigorous cost-benefit analysis.

3.4 Creating a Cost-Benefit Model

The general framework outlined by the New Starts legislation for FTA is the most relevant for our current assessment. But a clarification is required, as we have spoken somewhat loosely about “investment” in public transit. The theoretical and practical frameworks described above are largely designed for capital projects. In upcoming chapters, we will describe hypothetical public policy objectives that require a mix of capital and operating expenditures, spread out over a number of years. We believe that the cost-benefit framework – balancing the costs of planned public expenditures against expected benefits – is still the proper methodology to examine these objectives, provided that we account for the public cost of raising the funds via taxation. In fact, given that customers are likely to respond to service improvements in a relatively short timeframe (as compared to the many years or even decades that usually accompany a cost-benefit analysis for a major capital investment), we may find some surprisingly positive results.

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16 Illinois Compiled Statutes, 20 ILCS 3010, Sec. 3.
17 Illinois Compiled Statutes, 605 ILCS 5, Sec. 4-303.
18 Illinois Department of Transportation, Bureau of Railroads, Rail Freight Program (www.dot.state.il.us/rfp.html).
Early transportation analyses tended to focus almost exclusively on changes in in-vehicle travel time as the criterion for project benefits. Extensive research has expanded our understanding of the impacts of transportation investment, however, and there is now a broad compilation of major and minor benefits that can be included as part of the decision-making process.

3.4.1 Direct Benefits

The direct benefits of an expenditure on transit are those which accrue immediately to the travelers affected by the change in the transportation network. Improvements in in-vehicle travel time are the most obvious direct benefit. For example, the introduction of signal priority on a major arterial (one of the suggested components of bus rapid transit) will increase average bus speeds and generate in-vehicle travel time savings to transit passengers in that corridor. Of course, the potential for benefit is not limited to transit riders—transit service in a high-demand corridor can draw some auto users off the road, which improves the driving times of those travelers who continue to drive.

The second major category of direct benefits is improvements in out-of-vehicle time, and this category is especially important for transit. Generally this encompasses transfer time, waiting time, and access time, and studies have almost universally found that travelers find time spent out-of-vehicle as significantly more costly than time spent in-vehicle. For automobile travel, the total time spent out-of-vehicle can usually be optimized to be very small—transfers and waiting are unnecessary and walking access is generally short (especially at home). Often the only uncertainty arises from time spent searching for parking. For transit providers, especially one like the CTA whose passengers rely extensively on transfers, these out-of-vehicle time costs are crucial, and improvements here provide major benefits to users.

3.4.2 Indirect Benefits

The indirect benefits of a transit expenditure are no less real than the direct benefits, but they can be harder to identify and quantify because they accrue outside of the production of the transit service. Reductions in environmental externalities—improvements in air quality and water and noise pollution—are the primary indirect benefit which accrues to the region as a whole. The Chicago metropolitan region, for example, has been designated by the Environmental Protection Agency as a “severe non-attainment” area for ozone, and transportation sources (both auto and transit) are major sources of ozone precursors. A shift of travelers towards
transit and away from private automobiles will reduce vehicle miles traveled, and if the transit service is sufficiently heavily utilized, the net emissions in the region may be reduced.

A second category of indirect benefit which has received some academic treatment recently is option value. Many travelers in an area served by transit will not choose transit for their commuting journey or for typical non-work journeys and will travel by automobile instead. However, the transit network still has value to these people for infrequent or unanticipated trips - that is, the option of using transit has benefit even if it is rarely or never selected. The classic example is using transit while an automobile is being repaired, but the occasional trip into downtown for an athletic event (when parking would be very expensive) or availability for visiting guests also can be evaluated in this framework. Valuation of such a "real option" is not as simple as evaluating a financial option (e.g., using Black-Scholes), but clearly such benefits exist and are one reason that transit draws public support even from those who almost never use it.

3.4.3 Double-Counting of Benefits

As noted earlier, the benefits which flow from a transportation investment or expenditure can be transferred from travelers to other actors in the economy, and the analyst must be cautious not to double-count such benefits. When the construction of a heavy rail transit line raises property values in areas surrounding the new stations, for example, this incremental value is not additive to the direct travel-related benefits of the rail line. Rather, the higher prices reflect a (partial) capitalization of those travel-related benefits.

If the investment or expenditure is large enough to encourage a significant change in land use patterns, however, it is possible that additional benefits will be generated that are independent of the original travel-related benefits. Rail transit stations, for example, can encourage more dense development in their immediate vicinity. Because of the higher density, this development may be cheaper (on a per-unit basis) to service with public facilities such as utilities and emergency services. Large cities which are well-served by transit may also have added labor market efficiencies (employers and workers are easier to "match up") and agglomeration efficiencies (the density of firms increases competition and lowers transaction costs).

In this analysis, we will not consider possible changes in property value that might flow from the proposed changes in transit provision, and will instead focus directly on the mobility, congestion, and air quality benefits. Moreover, in an already-dense city with an established
transit network like Chicago, the likelihood of significant land use benefits from the expenditures being considered here seems remote. (The long-term land use impacts of a heavy rail investment such as the proposed Circle Line, conversely, will need to be significant if the project is to be justified.)

3.5 Valuing Benefits

This analysis considers potential transit investments and expenditures at a strategic level as a guide to public policy. To inform these choices, we need to bracket the potential benefits from the proposed changes. This can be accomplished with relatively simple benefit models using aggregate measures. After the high-level assessment, the evaluation of specific projects, such as the introduction of an express bus service in a particular corridor, would require disaggregate travel demand modeling which is beyond the scope of the analysis presented here. In addition, we speak here of the benefits flowing from an improvement in service, but the same assessments can and will be made regarding a loss of benefits if service is reduced or fares are increased.

3.5.1 Mobility Changes

A significant fraction of the benefits from the proposed transit service improvement will come in the form of mobility improvements for transit riders. The most comprehensive way to gauge these benefits is to estimate the gain in consumer surplus for these riders. By adding and improving service, the generalized (overall) user cost associated with transit is reduced, which both benefits existing passengers and draws in new transit riders.

The shaded areas in Figure 3-6 represent this gain in consumer welfare. A linear demand curve is shown, which for moderate changes in cost and ridership is a standard simplification. The larger rectangle on the left of the represents the gain to people already riding the transit system whose trip-making behavior remains the same following the service improvement. The smaller triangle on the right is the gain accruing to those new transit passengers. By reducing user cost from GC₀ to GC₁, ridership increases from T₀ to T₁. The total change in consumer surplus is then:

\[ \Delta B = \left( \frac{T_0 + T_1}{2} \right) (GC_0 - GC_1) \]
Measuring changes in transit trip volume is simple, given the ridership generation modeling of the previous chapter. (We are choosing to measure volume with passenger trips rather than passenger-miles, but either could be used.) Estimating user costs per trip, however, is more challenging. The generalized user cost function will have three major components: out-of-pocket costs, in-vehicle travel time, and out-of-vehicle time.

Figure 3-6: Gains in Consumer Surplus

- Out-of-pocket costs: Under a service improvement scenario, out-of-pocket costs (i.e., fares) will remain constant and will net out of the calculation.
- In-vehicle travel time: Two important estimates are required here – the value to the passenger of each minute of travel time saved, and the average number of minutes saved following the service expansion.
- Out-of-vehicle time: A second estimate of the value of time is required here, in addition to estimates of the average amount of time saved in each of the out-of-vehicle categories (access, transfer, and waiting).
3.5.2 Congestion

As travelers move from the automobile to transit in response to the improved service, the reduction in vehicle miles traveled (VMT) will lower the cost of congestion in the region. A rigorous determination of the changes in corridor-level travel times and congestion levels requires a detailed traffic simulation and planning model, but we can generate an estimate of the expected gains from a reduction in VMT by utilizing historical congestion data for Chicago from the Texas Transportation Institute’s (TTI) annual Mobility Survey.

Figure 3-7 displays twenty years (1982-2001) of VMT and congestion cost data from TTI for the Chicago metropolitan area. Estimated daily VMT on highways and principal arterial roads are shown on the horizontal axis, while constant-dollar congestion costs (in 2001 dollars) are given on the vertical axis. In those twenty years, daily VMT in the region doubled from approximately 45 million to over 90 million. But annual real congestion costs are estimated to have quadrupled, from $1 billion to over $4 billion. A simple least-squares regression gives a relationship between growth in VMT and growth in real costs which can use to perform ‘what-if’ estimates of the benefits from reducing VMT growth. Of course, the true relationship between vehicle miles traveled and congestion at a micro level can be significantly non-linear, but the TTI data will at least allow a bracketing of the likely values. In addition, using only data from the previous ten years, the congestion cost of incremental VMT appears to be higher than that shown here, which is an expected result as the region gets larger and more congested. We will present results using estimates from this shorter period.
3.5.3 Air Quality Changes

Pollution represents the major uncompensated externality from surface transportation, whether from gasoline-powered private vehicles, diesel trucks and motor buses, or generating plants which supply the power to electrified heavy rail transit. We focus here only on the human health costs of air pollution, which research has indicated accounts for a significant majority of the total external environmental costs of motor vehicle usage in the United States (see, for example, Delucchi 2000). However, the additional negative environmental effects of motor vehicle usage – visibility losses and crop damage from air pollution, noise and water pollution, and the hard-to-estimate effects of greenhouse gases – should be included in any public decision-making process.

Fortunately, the past thirty years have seen a great improvement in transportation-related pollution in the United States. Following the passage of the 1970 Clean Air Act and its subsequent amendments, which enacted increasingly strict motor vehicle emissions restrictions, aggregate emissions (in tons) of the six “criteria” pollutants fell by 48%. Figure 3-8 below, from
the EPA, shows the significant reductions achieved for carbon monoxide, volatile organic compounds, and sulfur dioxide, as well as the 98% reduction in lead pollution following the elimination of leaded gasoline.

![Comparison of 1970 and 2002 Emissions](image)

Figure 3-8: Criteria Pollutant Emissions in the U.S.
(from the US EPA)

Despite these gains, however, the health costs associated with motor vehicle air pollution – especially from particulate matter – are still of concern. If additional investments and expenditures on public transit can reduce overall vehicle miles traveled, then the resulting changes in air quality should be included in a benefit/cost estimation. We will use the recent work by McCubbin and Delucchi (1999) as a primary source for estimating these benefits, following the lead of the TCRP in its handbook. Using their high and low estimates of the environmental costs of motor vehicle travel, in conjunction with our model predictions of changes in private automobile VMT and diesel motor bus VMT, we can bracket an estimate of the monetary value of changes in air quality. Figure 3-9 shows their estimates of the per-mile air pollution costs for light-duty gasoline vehicles (LDGV) and heavy-duty diesel vehicles (HDDV). The 'v' figures represent tailpipe emissions only, while 'v+u' figures represent tailpipe plus upstream pollution.
Cost per Mile of Motor Vehicle Travel,  
based on a 10 per cent Reduction in Motor-Vehicle-Related Emissions  
(cents per vehicle mile travelled in the USA in 1990)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Emission Source</th>
<th>Particulate Matter (PM)</th>
<th>Ozone (O₃)</th>
<th>Carbon Monoxide (CO)</th>
<th>NO₂</th>
<th>Other Toxics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>LDGV</td>
<td>v</td>
<td>0.48</td>
<td>7.02</td>
<td>0.01</td>
<td>0.07</td>
<td>0.04</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>v+u</td>
<td>0.56</td>
<td>7.50</td>
<td>0.01</td>
<td>0.07</td>
<td>0.04</td>
<td>0.37</td>
</tr>
<tr>
<td>HDDV</td>
<td>v</td>
<td>4.18</td>
<td>79.93</td>
<td>0.02</td>
<td>0.19</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>v+u</td>
<td>4.43</td>
<td>81.37</td>
<td>0.02</td>
<td>0.20</td>
<td>0.01</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Figure 3-9: McCubbin/Delucchi (1999) Estimates of Air Pollution Costs Per VMT

3.6 Conclusion: Creating a Baseline

We have outlined the challenges facing public transit in Chicago and across the U.S., both in terms of political and market constraints and in terms of relatively stagnant measures of internal performance. We have also identified a coherent theoretical framework for costs and benefits with which to evaluate potential investments in those transit systems. Now, in Chapters 4 and 5, we will examine baseline projections in Chicago and then create a specific cost model to test various investment and expenditure possibilities.
4 Baseline: Preventing Ridership Loss

In Chapter Two, we identified some of the long-standing historical and political constraints facing public transportation in Chicago, and in Chapter Three we examined different measures for evaluating public transit’s performance. Before using this framework to consider any long-term structural changes, however, the looming operational crisis at the CTA must be analyzed. Facing a stagnant regional economy and a reduction in public funding, the CTA acted to avert a crisis in 2004 without resorting to service cuts by raising base fares. If a significant change in available public support is not forthcoming, the crisis will expand in 2005 and later years. In order to meet the fiscal requirements of the Regional Transportation Authority, the CTA will be forced into a combination of significant fare increases or heavy cuts in service.

4.1 Fare Policy at the CTA

Figure 4-1 shows the progression of real and nominal CTA base fares since 1978, as well as the average farebox revenue received by the agency per unlinked trip. The pattern for nominal fares is clear, with long periods at a constant fare broken by shorter crisis periods with one or more fare increases. The CTA had in fact held nominal base fares constant at $1.50 for a decade. Real base fares have had a “floor” of approximately $1.40-$1.50 in 2003 dollars – whenever fares have reached that level, they have been pushed back up (including the most recent 2004 fare hike). Nominal revenue per unlinked trip has risen fairly steadily throughout the period, except for the years 1998-2000 when the introduction of electronic fare media and increasing discounts off the base reduced the agency’s average fare slightly. Interestingly, the agency is currently receiving approximately the same real revenue per trip as it did 25 years ago, despite the massive changes that the system and the city have undergone.
Figure 4-1: CTA Fares and Per-Trip Revenue (1978-2005)

Figure 4-2 then maps real fares and real farebox revenue per trip against total bus and rail ridership (unlinked trips). We see clearly that the two periods of greatest ridership loss were contemporaneous with the financial crisis periods where fares were raised most sharply. These periods – during the early 1980s and the early 1990s – are described more fully in Table 4-1. In each case, a 50% increase in base fares resulted in a 34% increase in average fare per unlinked trip and significant ridership losses in both periods. Of course, the ridership declines were not caused only by the fare increases, as service cuts and stagnant or falling economies were also strong factors in both periods. However, the transit environment in 2004 is not dissimilar, and similar fare increases are not outside of the CTA’s current consideration.
CTA Real Fares and Revenue/Trip vs. Ridership

Figure 4-2: CTA Fares, Revenue, and Ridership (1978-2004)

<table>
<thead>
<tr>
<th></th>
<th>Early 1980s*</th>
<th>Early 1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Year</td>
<td>1980</td>
<td>1990</td>
</tr>
<tr>
<td>End Year</td>
<td>1981</td>
<td>1993</td>
</tr>
<tr>
<td>Nominal Base Fare</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>$0.60</td>
<td>$1.00</td>
</tr>
<tr>
<td>End</td>
<td>$0.90</td>
<td>$1.50</td>
</tr>
<tr>
<td>% Change</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Nominal Revenue/Trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>$0.31</td>
<td>$0.60</td>
</tr>
<tr>
<td>End</td>
<td>$0.41</td>
<td>$0.80</td>
</tr>
<tr>
<td>% Change</td>
<td>34%</td>
<td>34%</td>
</tr>
<tr>
<td>Annual Trips (000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>692,430</td>
<td>567,461</td>
</tr>
<tr>
<td>End</td>
<td>642,804</td>
<td>444,923</td>
</tr>
<tr>
<td>% Change</td>
<td>-7.2%</td>
<td>-21.6%</td>
</tr>
</tbody>
</table>

*Ridership change 1979-1982 was -14%*

Table 4-1: Periods of Financial Crisis at the CTA
4.2 Financial Projections and Ridership Implications

The "budget marks" given to the CTA for 2004 budget planning indicate that the public funding available to the agency from the RTA will be $441.6 million for each year from 2004 to 2006. This figure is not only decreasing in real value over time, but also is a decrease in nominal terms from public funding available in 2003. The combination of a stagnant regional economy and continued below-inflation rate growth of tax receipts in Cook County is the stated reason for this budget mark. This level of funding will severely impact the CTA’s ability to provide continuing levels of service, and increases in petroleum and power prices in 2004 (subsequent to the budget marking) have made the situation even more tenuous.

A consolidated CTA statement of expenses and revenues for 2003-2006 is given in Table 4-2. Figures for 2003 are projected (not yet finally confirmed) and 2004 figures represent the officially accepted 2004 budget. The 2005-06 figures are planning forecasts and have not been accepted by the RTA.

(all figures in 000s)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Expenses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>$662,228</td>
<td>$687,528</td>
<td>$701,881</td>
<td>$718,747</td>
</tr>
<tr>
<td>Material</td>
<td>63,500</td>
<td>66,000</td>
<td>67,500</td>
<td>65,000</td>
</tr>
<tr>
<td>Fuel (Revenue Equipment)</td>
<td>23,995</td>
<td>23,000</td>
<td>24,840</td>
<td>24,840</td>
</tr>
<tr>
<td>Electric Power (Rev. Equip.)</td>
<td>20,100</td>
<td>22,000</td>
<td>23,000</td>
<td>23,000</td>
</tr>
<tr>
<td>Injury/Damage Provision</td>
<td>17,568</td>
<td>22,000</td>
<td>19,000</td>
<td>27,000</td>
</tr>
<tr>
<td>Security</td>
<td>24,800</td>
<td>25,042</td>
<td>25,794</td>
<td>26,567</td>
</tr>
<tr>
<td>Paratransit</td>
<td>41,000</td>
<td>45,113</td>
<td>46,918</td>
<td>48,325</td>
</tr>
<tr>
<td>Other Expenses</td>
<td>40,500</td>
<td>45,945</td>
<td>47,323</td>
<td>48,743</td>
</tr>
<tr>
<td>Total Operating Expenses</td>
<td>$893,691</td>
<td>$936,628</td>
<td>$956,256</td>
<td>$982,222</td>
</tr>
</tbody>
</table>

| System Generated Revenue     |           |           |           |           |
| Fares and Passes             | $367,000  | $394,512  | $421,031  | $438,758  |
| Reduced Fare Reimbursement   | 32,300    | 32,300    | 32,300    | 32,300    |
| Advertising, Charter, Concessions | 22,000 | 24,250    | 26,250    | 30,750    |
| Investment                   | 2,415     | 3,000     | 3,000     | 3,000     |
| Local Government             | 5,000     | 5,000     | 5,000     | 5,000     |
| Other Revenue                | 11,488    | 35,935    | 27,042    | 30,783    |
| Total System Revenue         | $440,203  | $494,997  | $514,623  | $540,591  |

| Public Funding Required      | $453,488  | $441,631  | $441,633  | $441,631  |

Fraction of Operating Expenses Covered By Fares and Passes

|               | 41.1%      | 42.1%      | 44.0%      | 44.7%      |

Table 4-2: CTA Revenues and Expenses (2003-06)
The figures presented in the financial plan contain the approaching crisis for the CTA. In this proposal, total operating expenses are projected to grow at approximately 3.2% annually from 2003 to 2006, with labor costs (which constitute over 70% of operating expenses) growing at a slightly slower rate of 2.8%. These growth rates are in line with general inflation expectations, although certain expense components such as health care are projected to grow at rates exceeding inflation. But the zero growth in available public funding forces system generated revenue to grow at a rate of over 7% per year, with fare and pass revenue increasing at over 6% per year. Sustained (year over year) growth in farebox revenue of this magnitude is simply without precedent in the CTA's postwar history. No ridership projections accompany the revenue figures, but we can create simple scenarios which might explain or reconcile such projections.

4.2.1 Scenario A: Constant Average Fare Revenue Per Trip

The budgeted average farebox revenue per trip in 2004 is $0.87. If this ratio were to hold constant in 2005-06, it would imply 483 million total unlinked trips in 2005 and 503 million trips in 2006. This would require ridership growth of almost 6.7% from 2004 to 2005 and 4.2% from 2005 to 2006. Ridership growth on this scale has occurred before - the two-year ridership growth from 1997 to 1999 was of similar magnitude. But that growth had a constellation of positive causal factors: it occurred at the height of the late-1990s economic boom, after five years of a constant fare, and after the CTA “bottomed out” following a round of painful service cuts. To plan for such growth, only one year after a fare increase and without any reasonable expectation of returning to such a strong economic environment, seems highly unlikely.

4.2.2 Scenario B: Reasonable Ridership Growth

A more reasonable (but still aggressive) expectation for ridership growth might be 2% per year, implying 457 million passengers in 2005 and 471 million passengers in 2006. Such a projection is problematic, though, for it implies that ridership will increase at the same time that average fare per trip is also rising significantly - to $0.91 per trip in 2005 and $0.93 in 2006. Standard assumptions about the shape of the demand curve for transit argue against this, and the recent history of the CTA does as well - in the periods of increasing ridership from 1982-1985 and 1997-2001, the nominal average fare revenue per trip stayed flat or declined. This scenario also seems like an unlikely candidate for the CTA.
4.2.3 Scenario C: Significantly Higher Fares

Suppose that the upcoming financial crunch forces a repeat of the experiences of the early 1980s and 1990s. Here we envision a similar fare hike occurring in stages from 2003 through 2006. A 50% increase in the base nominal fare from its 2003 level would put the cost of a one-way trip on the CTA at $2.25 by 2006. This is certainly not an implausible figure - the base fare on New York City Transit was recently increased to $2.00, and the rush-hour fare in the Washington, DC, metro area for many longer subway trips is $3.00 or more. We then assume that per-trip average revenue would be $1.00 in 2005 and $1.10 in 2006 (a 34% increase from 2003 levels). These figures imply ridership levels of 421 million trips in 2005 and 399 million in 2006 – a loss of 49 million trips, or 11%, from 2003. This heavy loss is well within the range of experience from the previous two fare increases.

4.3 Costs of Ridership Loss

The higher fares scenario is the most realistic of the three presented above. A relevant question which arises, then, is the level of added public funding which would be required to mitigate the ridership losses in 2005-06 without additional fare increases or service cuts. If we assume constant (zero-growth) ridership at 453 million per year in 2005 and 2006, and also a constant average fare per trip of $0.87, then fare and pass revenue will be $395 million in each year. If all other revenue and expense items remain the same, the public funding gap would be $26.5 million in 2005 and $44.2 million in 2006. Additional funding at this level in 2006 would essentially cover the paratransit expenses that are so costly for the CTA to provide, although such funding would violate the existing recovery ratio requirements. A portion of this increase could come simply from increases in tax revenues if the economy outperforms expectations, but the recent experience of tax revenue growth in Cook County indicates that a change in the RTA taxing structure would be required to achieve this level of funding. What would be gained by this additional public funding?

4.3.1 Alternative Travel Mode

If 50 million annual transit trips are lost in 2006 (versus 2003) because of a fare increase, these trips must "go someplace." A survey by McCollum Management in 1999 (and quoted as Table 10-18 in the TCRP “Traveler Response...” Handbook) of bus riders in Chicago and other cities determined the riders' alternative travel mode if transit were unavailable. This is not the same as alternate mode choice in response to a transit fare increase, and we expect that the
response among heavy rail riders would be more strongly weighted toward the automobile. However, it at least provides a reasonable baseline for estimating what happens to lost transit trips. The Chicago data are presented in Table 4-3.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>14.0%</td>
</tr>
<tr>
<td>Ride w/ Someone</td>
<td>23.7%</td>
</tr>
<tr>
<td>Walk</td>
<td>15.2%</td>
</tr>
<tr>
<td>Taxi</td>
<td>16.1%</td>
</tr>
<tr>
<td>Bicycle</td>
<td>2.9%</td>
</tr>
<tr>
<td>Not Make Trip</td>
<td>23.8%</td>
</tr>
<tr>
<td>Multiple Answers</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

Table 4-3: Alternate Modes For Chicago Bus Riders

We see that nearly one-quarter of bus riders say they would simply abandon their trips if transit were not available, while almost 40% would shift to auto (either alone or as a passenger) and the rest would walk, bike, or use a taxi. These figures are similar across the other cities surveyed by McCollum, though the taxi fraction is higher in Chicago, which is unsurprising. These estimates can guide an estimation of losses suffered by travelers.

4.3.2 Consumer Surplus Loss to Existing Travelers

The largest burden from the fare increase described in Scenario C above is borne by continuing transit riders. If the service provided by the CTA remains constant across the network, so that average travel times and out-of-vehicle (transfer, waiting, and access) times stay roughly the same across the ridership base, then the increase in generalized user cost will simply be the increase in fares. (This is a conservative estimate, since the CTA would likely trim some services in response to the ridership decline, thus worsening non-fare travel costs for existing riders.) If the average fare per trip has increased $0.23, from $0.87 to $1.10, and each of the remaining 399 million trip-makers bears this increase in cost, then the consumer surplus loss for 2006 will be $91.1 million.

4.3.3 Trips Shifted

If we assume that 20% of trips are foregone, which is in line with the survey results above, then the remaining 80% of trip-makers have found alternate travel modes for reaching their destinations. For these travelers, it is appropriate to use the "rule of one-half" (assuming a linear demand curve) to estimate their loss in consumer surplus. Assuming again a $0.23
increase in average fare, the consumer surplus loss to these 39.6 million trip-makers (80% of at 49.5 million total) will be approximately $4.5 million.

4.3.4 Abandoned Trips

Estimating the loss associated with abandoned trips is more challenging. Riders who completely forego trips following a fare increase are likely to be those who are the poorest and most transit-dependent in the region, and these situations are harder to analyze within a standard benefit-cost framework. The value to the rider of her trip is likely to exceed the fare being charged, but she may face budgetary constraints which prevent her from translating this value into cash with which to pay the increased fare. We are hesitant to ascribe a particular dollar value to these lost trips, but they should not be ignored. Even if these abandoned trips had an intrinsic value of only $1.00 per trip, this would represent a loss to consumers of $10 million in 2006.

4.3.5 Congestion Costs

The shift away from transit potentially has additional congestion costs that will be borne by existing auto travelers and truck drivers in the region. However, given the dominance of automobile travel, the number of incremental vehicle miles traveled (VMT) likely to be added to the Chicago road network, even following a substantial fare increase, is relatively small compared to overall VMT. Table 4-4 gives an order-of-magnitude estimation of the added daily VMT that would result. Assuming an average trip length of 5 miles (which is shorter than the trip length assumed by TTI, but approximately equal to the current average CTA rail trip and longer than the average CTA bus trip), total daily travel on highways and arterials would increase by 132,000 vehicle miles per day. This is less than 0.2% of the projected total daily highway and principal arterial VMT in the region.\(^{19}\)

---

\(^{19}\) This calculation assumes 1% annual growth in highway and principal arterial VMT for 2002-2006, which is in line with recent historical experience.
<table>
<thead>
<tr>
<th><strong>Steady Ridership Level</strong></th>
<th>448,386,000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ridership With High Fares (Scen. C)</strong></td>
<td>398,870,909</td>
</tr>
<tr>
<td><strong>Loss in Annual Unlinked Trips</strong></td>
<td>49,515,091</td>
</tr>
<tr>
<td><strong>Average Unlinked Trips Per Linked O-D Trip</strong></td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Loss in Linked Trips</strong></td>
<td>33,010,061</td>
</tr>
<tr>
<td><strong>Fraction Shifting to New Mode</strong></td>
<td>80%</td>
</tr>
<tr>
<td><strong>New Non-Transit Trips</strong></td>
<td>26,408,048</td>
</tr>
<tr>
<td><strong>Fraction of Trips Shifting to Incremental Auto Trip</strong></td>
<td>25%</td>
</tr>
<tr>
<td><strong>New Auto Trips</strong></td>
<td>6,602,012</td>
</tr>
<tr>
<td><strong>Days Per Year</strong></td>
<td>250</td>
</tr>
<tr>
<td><strong>New Daily Auto Trips</strong></td>
<td>26,408</td>
</tr>
<tr>
<td><strong>Average Trip Length (mi.)</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Incremental Daily VMT</strong></td>
<td>132,040</td>
</tr>
<tr>
<td><strong>Original Projected Daily Highway and Principal Arterial VMT in Chicago Region</strong></td>
<td>96,798,000</td>
</tr>
<tr>
<td><strong>Incremental VMT Increase</strong></td>
<td>0.14%</td>
</tr>
</tbody>
</table>

*Assume all transit trip losses occur on standard work days.

**Table 4-4: Increase in 2006 VMT Under Fare Increase Scenario**

However, even such a marginal increase may have negative effects on regional welfare. Using the historical TTI data on VMT and costs of congestion described in Chapter Three, we can estimate the additional annual costs imposed by this increased travel. Using the parameters from the OLS regression on the previous ten years of data (which appears more reasonable and indicates a slightly higher congestion cost for added VMT than the twenty-year sequence), we can estimate the incremental regional congestion costs that will accompany the fare increase. Table 4-5 shows this estimated congestion cost (or dis-benefit) for 2006 using a range of estimates for average trip length and fraction of trip-makers making their trip by “incremental” auto (i.e., by making a new auto trip, rather than walking, sharing a ride with an existing driver, etc.).

Clearly, this estimate is very sensitive to assumptions, as we see a four-fold range (from $8 million to $37 million) across fairly plausible parameter choices. Given existing travel patterns in Chicago, the grey-boxed estimate of $13.4 million (with average trip length of five miles and 25% new auto trips) appears to be the most reasonable. For the purposes of a strategic evaluation of policy, we believe this level of accuracy is sufficient, but an implementation of these policies would of course require more detailed travel behavior modeling.
Assessing the cost of diminished air quality following the fare increase involves even greater uncertainty than that associated with estimating congestion costs. The range of "reasonable" costs given by McCubbin and Delucchi (see Chapter Three) covers a greater than ten-fold difference between low and high estimates. Moreover, modeling of air quality impacts is even more dependent than congestion modeling on microscopic and site-specific characteristics (the age and composition of the auto fleet, the climate and season, the health attributes of the local population, and so forth), and we do not undertake such microscopic analysis here. However, it will still be instructive to compare estimates of air quality impacts with more definite changes in consumer welfare (such as fares or travel time) and see if the orders of magnitude are similar or widely different.

First, however, a few words about the estimates by McCubbin and Delucchi are required. In the interest of conservatism, so as not to overstate the potential impact, we will focus on their low range estimates. Despite this, the effects of air pollution will be notable in our overall benefit/cost estimates. Also, it is significant that the vast majority of human health effects from motor vehicle pollution come from particulate matter – between 80-90% for gasoline vehicles and well over 90% for diesel vehicles. This will have an impact in later scenarios where increases in service provision will put more diesel motor buses on the road in place of gasoline vehicles.

It is also important to recognize that these estimates are derived from data on the 1990 automotive fleet. The dollar figures must of course be adjusted for inflation, but more importantly, the average light-duty gasoline vehicle in 2004 produces significantly less pollution than the average vehicle in 1990. However, these Clean Air Act-mandated improvements are mitigated by two factors. First, there has been a significant growth since 1990 in the use of trucks and sport utility vehicles as passenger cars, and these vehicles have less efficient engines which burn more fuel and emit more pollutants per mile. Second, the travelers...
in our scenarios who are most likely to be switching modes between auto and transit are also likely to be low- or moderate-income. These travelers will also likely use cars that are older and less well-maintained, and hence more polluting, than the current fleet average. In order to deal with these effects, we will present two sets of estimates – one using the original (inflation-adjusted) pollution costs per mile, and one assuming that the average car affected in our various scenarios is only half as polluting as the average car in 1990. We believe this will cover a reasonable range of estimates for pollution costs.

As in the congestion calculations above, we project that 25% of shifted trip-makers will undertake a new automobile trip. In addition, we will assume for simplicity that all new trips occur in light-duty gasoline vehicles. Table 4-6 presents a range of estimates for the costs of tailpipe and upstream emissions. Under our “most reasonable” scenario above (and boxed in grey), and assuming the average vehicle is half as polluting as the average 1990 vehicle, the air pollution costs under the fare increase scenario are approximately $15 million (in 2004 dollars).

<table>
<thead>
<tr>
<th>Average Auto Pollution Level</th>
<th>Average Trip Length (mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>PM</td>
</tr>
<tr>
<td>Same as 1990 Fleet Average</td>
<td>$15.6</td>
</tr>
<tr>
<td>One-Half of 1990 Average</td>
<td>$7.8</td>
</tr>
</tbody>
</table>

*(figures in millions of 2004 dollars)*

Table 4-6: Air Pollution Cost Estimates Under Fare Increase Scenario

### 4.3.7 Evaluation

When we consider both continuing transit riders and lost riders, the loss in consumer benefit under the higher fares scenario is at least $100 million in 2006. Losses due to increased road congestion are likely to be in the range of $10-$15 million, while human health costs from increased air pollution (predominately particulate matter) are of a similar magnitude – approximately $15 million. All together, the direct costs and the external costs of this shift from transit to automobiles in response to higher fares are on the order of $130 million by 2006. This is significantly in excess of the $44 million estimated as the additional public funding needed to keep average fare revenue and ridership in 2006 constant at their 2003 levels.

The $44 million in public funding is not “free,” however. There can be significant deadweight losses associated with tax collection. In their assessment of transit subsidies, Savage and Schupp reference Jorgenson and Yun (1991) and estimate an additional cost of public funds when generated by a sales tax (from the deadweight loss associated with taxation)
of 26% on top of the amount raised. Using this figure, the total cost of maintaining fare levels and system ridership increases to $55 million in 2006. Even with this cost included, however, the ratio of expected benefits to costs of this expenditure is approximately 2:1.

This estimation may in fact understate the costs (or dis-benefits) associated with the ridership loss. While many travelers who shift their trips away from transit to the automobile will use existing cars (either carpooling or driving a currently-owned vehicle), some fraction will actually purchase incremental new automobiles. The overall travel behavior of these persons (or households) is then likely to change, because the marginal cost of an additional auto trip is now quite low. Other trips which might previously have been achieved by walking or sharing a ride now have an auto available, and entirely new trips are also likely to be created. This induced auto travel will worsen regional congestion and air quality, and the dis-benefits will thus be larger than those calculated here. However, further research is required to correctly estimate such effects, and we have not included them here.

4.4 Conclusion

The analysis above makes a strong case that allowing the CTA to descend into financial crisis, as happened previously in the early 1980s and 1990s, is a poor public policy choice. The costs (or dis-benefits) to transit riders, auto drivers, and the general population that are likely to occur are significantly larger than the expenditure required to prevent the crisis. With that baseline established, we now want to move to the next level and determine the costs and benefits of further public investment and expenditure to gain transit riders, rather than simply to hold ridership constant. We explore various scenarios for ridership gain in Chapter Five.
5 Ridership Growth I: Objectives and Costs

In Chapter Two, we established the motivation for our investigation: that public transit, even during good economic periods, is serving a declining fraction of trips in U.S. metropolitan areas, and that this continued shift is due in part to historical and current constraints placed on transit which are not faced by the automobile. If this trend is to be reversed, and the related problems of auto and truck congestion addressed, more public expenditure on transit is likely to be necessary. Then, in Chapter Three, we covered two related frameworks for assessing the potential gains (or losses) from this hypothesized investment. First, measures of efficiency and effectiveness were introduced, which serve as internal indicators of transit performance and the nature of the transit production function. Second, an external cost-benefit framework was described, where the passenger trips produced by a transit system are translated into benefits which can then be balanced against the required public expenditures. Finally, in Chapter Four, we analyzed the current constrained position of the CTA using this framework. We found that an increase in funding for the CTA in order to stave off an anticipated fare increase would be justified when the likely benefits in mobility, congestion, and air quality are balanced against the public costs.

We now want to further develop this general framework and examine in detail the costs and benefits of using additional public expenditure to not simply hold ridership constant, but to increase the ridership of public transit in the city of Chicago. More specifically, we want to answer the following questions:

1) Can we create a system-level (as compared to route-level) methodology – one which is sensitive to assumptions on both service provision and customer response – for modeling potential ridership gains in response to additional service provision?

2) Can this model identify investment objectives which are both a net positive for CTA and fit within existing constraints? And if existing constraints appear to be strongly limiting with respect to potentially positive expenditures, can we identify justifications for loosening the constraints?

3) Will the distribution of the benefits be localized within existing transit users or spread more broadly across residents and businesses in Chicago?

Chapter Five will introduce potential policy objectives and explain the creation of the one-period cost model, while Chapter Six will explore the accompanying costs and benefits across time.
5.1 Possible Objectives

With its many constituencies and social goals, the set of possible objectives for an incremental public transit investment is very large. We present three here which a) correlate with the benefits of public transit usually presented by transit agencies and advocates (see, for example, "The Benefits of Public Transportation" from the American Public Transportation Association), and b) are plausible goals to emerge out of a public policy process.

5.1.1 Congestion Mitigation

The "Annual Mobility Report" of the Texas Transportation Institute (TTI) analyzes congestion trends in major metropolitan areas. Using their Travel Time Index, which captures the amount of additional time needed to make a trip during a typical peak travel period in comparison to traveling at free-flow speeds, Chicago was ranked in 2001 as having the third-worst congestion in the country, despite having the nation's second largest transit system. In the ten years from 1991 to 2001, while population in the metro area grew at a rate of only 0.8% annually, vehicle miles traveled (VMT) on highways and principal arterials increased at a rate of 2.7% and per-person hours of delay grew by 4.4% per year. The estimated annual cost of this congestion to the economy of metro Chicago, counting both lost time and extra fuel, was $4.2 billion in 2001. This is a dead-weight loss to the region, as the lost time cannot be recovered and the expenditure on fuel (which provides no direct benefit to the consumer) could re-allocated to other goods. Therefore, one appealing public policy target is the diversion of incremental VMT growth into public transit in order to prevent further growth in congestion costs.

5.1.2 Household Transportation Expenditures

The average consumer unit (roughly a household) in the Chicago metro area spent approximately 14% of its income on transportation expenditures in 2001-02. This fraction has not changed significantly over the previous decade, decreasing slightly from 1991-92 as Table 5-1 indicates. Yet even in a transit-friendly area like Chicago, only 1% of income is spent on

\[ \text{20} \] However, the composition of that spending on transportation, when analyzed in real terms, has shifted. As real household income grew 21.6% over the period, transportation spending lagged, growing only 14.6%. But real net outlays on automobiles increased by 36% in the period, far ahead of real income growth. Households were able to afford some combination of additional automobiles and more
public transportation, and the bulk of transport spending goes to the purchase, maintenance, and insurance of private automobiles. This spending pattern has two potentially negative implications. First, expenditures on autos and petroleum products are likely to leave the Chicago region – to other regions and other countries – and thus be unavailable to have a multiplier effect on the Chicago economy. Second, income which must be spent on transportation cannot be used for housing and other consumer purchases. This relationship has recently been formalized by the Location Efficient Mortgage (LEM), a financial product developed in conjunction with the Center for Neighborhood Technology, which gives potential home-buyers in transit-rich neighborhoods additional borrowing power because their expected annual transportation expenses are lower. Thus, a second possible policy objective for transit is reduction of household transportation expenditures.

<table>
<thead>
<tr>
<th>Consumer Expenditure Category</th>
<th>1991-92</th>
<th>2001-02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Consumer Units (000)</td>
<td>3,227</td>
<td>3,072</td>
</tr>
<tr>
<td>Income Before Taxes</td>
<td>$39,106</td>
<td>$61,853</td>
</tr>
<tr>
<td>Average Number in Consumer Unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Vehicles</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Percent Homeowner</td>
<td>63</td>
<td>69</td>
</tr>
<tr>
<td>Average Annual Expenditures</td>
<td>$34,105</td>
<td>$47,861</td>
</tr>
<tr>
<td>Food</td>
<td>$4,867</td>
<td>$5,934</td>
</tr>
<tr>
<td>Housing</td>
<td>$11,160</td>
<td>$17,239</td>
</tr>
<tr>
<td>Transportation</td>
<td>$5,751</td>
<td>$8,571</td>
</tr>
<tr>
<td>Vehicle purchases (net outlay)</td>
<td>2,296</td>
<td>4,061</td>
</tr>
<tr>
<td>Gasoline and motor oil</td>
<td>1,011</td>
<td>1,327</td>
</tr>
<tr>
<td>Other vehicle expenses</td>
<td>1,926</td>
<td>2,476</td>
</tr>
<tr>
<td>Public transportation</td>
<td>518</td>
<td>707</td>
</tr>
<tr>
<td>Transportation % of Income</td>
<td>14.7%</td>
<td>13.9%</td>
</tr>
<tr>
<td>Vehicle purchases (net outlay)</td>
<td>5.9%</td>
<td>6.6%</td>
</tr>
<tr>
<td>Gasoline and motor oil</td>
<td>2.6%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Other vehicle expenses</td>
<td>4.9%</td>
<td>4.0%</td>
</tr>
<tr>
<td>Public transportation</td>
<td>1.3%</td>
<td>1.1%</td>
</tr>
</tbody>
</table>

Table 5-1: Consumer Expenditures in Chicago (Nominal Dollars)

expensive automobiles because their average real expenditures on fuel, insurance, maintenance, and other vehicle expenses were essentially constant over the period.
5.1.3 Ridership Gain

The postwar history of the CTA is characterized by periods of relatively flat ridership punctuated by shorter periods with substantial decreases in patronage. In 2002, CTA carried approximately 455 million unlinked trips on its bus and rail networks. This represents a drop of approximately 15% from its level of 1991, when the CTA experienced a sharp ridership decline in conjunction with the national recession. Many Chicago politicians and business advocates (such as the Chicago Metropolis 2020 group) would like to reverse these postwar trends. Moreover, at the national level, the Federal Transit Administration has set a goal of 2% annual growth in transit ridership. While many smaller transit providers may actually be able to grow faster than this, the sheer size of the transit agencies in New York, Chicago, and the other major cities requires that they grow at nearly this rate in order to achieve the national goal. Thus, a third potential public policy goal is recapture of previous ridership levels and a reversal of the continued decline in transit mode share.

5.1.4 Effectiveness of Fare Reductions?

Throughout this analysis, we will essentially consider fare levels as an exogenous constraint on the CTA and focus instead on the costs and benefits of service expansion. In the short-term, this is not an unreasonable assumption, as explicit political constraints (RTA fare recovery requirements) prevent fare reductions and implicit constraints (voter unhappiness) prevent frequent or sizable fare increases. However, it will be instructive to briefly look at the costs and benefits of the various investment scenarios and see if a comparable amount of public funding used for fare reductions would have a comparable effect on achieving the stated policy objectives.

5.2 Methodology

Figure 5-1 illustrates the basic flow of the investment process and shows the causal links between the major components of the model. For a given incremental amount of public investment, additional service can be provided by the buses and trains. (If this service is being provided in the off-peak, the funding may go only for operations, while a proposal for added peak service may require additional capital funds for vehicle purchases. This distinction will be examined in greater detail.) This new service should draw additional riders onto the transit system, and the consumer response to the increased level of service is likely to vary across time period and mode. In addition, these new transit trips may be travelers switching from
automobile, or switching from a non-motorized mode such as walking, or even undertaking entirely new trips. From this breakdown of amount and source of new riders, we can estimate the benefits flowing from the proposed investment.

**Figure 5-1: Schematic of Causal Relationships**

However, despite the causal relationship which flows left-to-right above, we will approach the actual cost and benefit estimation in *reverse*. That is, in order to meet the stated policy objective, we will determine the ridership changes required to achieve it, and then the added service and public expenditure required to generate that ridership. Once those costs and benefits have been established, we can then add in the “additional” benefits which will accrue from the investment to complete the picture – and those benefits could be substantial relative to the original policy objective.

### 5.3 Ridership Generation Model

The analysis would be greatly simplified if we could take the internal performance measure ‘operating subsidy per passenger’ and use it as a ridership generation parameter. In 2002, for example, the CTA reported public operating funding per trip of $0.97 on a ridership base of approximately 457 million passenger trips. If ridership creation were simply a matter of “scaling up” the existing operating system (abstracting for the moment from any physical or financial constraints), then a hypothetical 1% increase in trips carried would require an incremental public expenditure of only $4.4 million – a modest investment representing only 0.6% of the operating funding supplied by the RTA in the 2003 budget.

Of course, such an approach does not generate a realistic cost projection, but only a very loose lower bound estimate. The subsidy-per-passenger measure speaks only to the average performance across the transit network, hiding not only differences across mode and time of day, but also giving no information about *marginal* changes in cost and ridership, which are the focus here.
A finely detailed ridership generation model, one which would be applicable directly for agency planning, is beyond the scope of this investigation. In particular, such a model would require route-by-route examination of ridership patterns, transfer behavior, and timetable creation, among many other factors. Instead, we desire a model with a number of broad yet sensitive components which can help us gauge whether particular policy objectives are worthy of further examination. The model will focus on six major areas: mode split; peak vs. off-peak ridership; service elasticity (i.e., ridership response with respect to increased levels of service); operating costs; vehicle fleet size and capital costs; and average fare revenue.

5.3.1 Mode Split

Buses provide the majority of passenger transit trips in Chicago, as noted earlier. Table 5-2 below shows the modal split between bus and rail for Chicago and the three peer agencies from, with Houston METRO having only bus service (other services such as paratransit are omitted here). Two points are immediately clear from these data:

- Chicago provides significantly more bus service – and carries fewer rail passengers – than its two peers which have both bus and rail networks. The grid street network of Chicago, which supports cross-town (non-radial) bus trips, has a strong influence on this service pattern.
- The average rail trip is approximately twice as long as the average bus trip in Chicago and Washington, DC. If modal split is measured by passenger miles rather than passenger trips, then the picture shifts considerably, with rail holding a 55% share in Chicago. Houston bus trips are similar in length to Chicago and Washington, DC, rail trips, while Boston has much shorter average rail trips – a result of its dense urban form and its heavily-used light rail line.
Table 5-2: Mode Split and Trip Length

In this model, we will measure mode split using passenger figures, but the average trip length will be important when calculating benefits (e.g., vehicle miles removed from the roadway). Mode split will prove to be an important choice variable – will the agency simply “scale up” its existing system as it attempts to grow ridership, or will it target investment in a particular mode?

5.3.2 Peak/Off-Peak Ridership

Contrary to the perception (and reality) of transit in many cities, the CTA is not predominately a rush-hour service provider. According to internal market research, approximately 48% of all weekday trips on the CTA occur during the six peak hours (6-9 AM and 3-6 PM), with another one-third occurring in the mid-day and the rest during early morning, evening, or night owl periods. This service pattern is also reflected in the peak-to-base ratio, shown earlier in Chapter Three. The CTA’s peak-to-base ratio is low compared to its peers, which indicates a relatively strong provision of off-peak service and more efficient usage of its vehicles across the day.

As with mode split, the choice of peak versus off-peak investment will be important for the agency, and the correct choice may not be obvious. Demand elasticities are likely to be higher in the off-peak (i.e., passengers will respond more strongly to an increase in service), and the agency should be able to provide additional service without new capital outlays. However, the benefits of congestion mitigation will be significantly lower in the off-peak, thus raising doubts about the efficacy of the investment in reaching this policy objective.
5.3.3 Demand Elasticity

Customer response to additional service is a crucial component of the model. Yet there continues to be a lack of consensus in the transit industry about appropriate values for ridership elasticities. There are a number of issues:

- Shifts in ridership rarely occur in a "vacuum" where fares or service levels — that is, factors which are under the control of the transit agency — are the only parameters which change. Subsequent elasticity analysis can be confounded by economic, demographic, and technological changes that are difficult to identify.

- Many of the most detailed elasticity studies were performed during the 1970s when transit systems (both bus and rail) were expanding in response to growing state and federal investment. The growth in real income and auto ownership since that period has made the ridership base for transit less "captive," which may indicate that current customer response will be more elastic. However, changes in location patterns (employment, shopping, etc.) which have occurred, and which favor the automobile, may counteract that change. The balance between these factors is unclear.

- Short- and long-run demand elasticities may be substantially different, with short-run customer response expected to be more inelastic. For simplification purposes, we will assume only a single value, but this fact could potentially be troublesome for a transit agency. If customers are initially slow to respond to an improvement in service, the agency may feel pressure to retrench and cut the service back to its original level. This may further dampen customer responsiveness to service changes as households and employers feel they cannot make long-term location choices with confidence about transit service.

Given the scope of the public policy objectives outlined above, we are clearly considering more than simply lengthened hours on some bus routes or an improvement in off-peak frequency on the elevated trains. Instead, we are considering a comprehensive service expansion. Such an expansion will ultimately be measured as an increase in revenue vehicle miles, but it could include a mix of expanded hours, increased frequencies, coverage in new areas, and introduction of express services.

The recent TCRP report "Traveler Response to Transportation System Changes" provides the most inclusive overview of ridership studies on U.S. transit properties, and they find that the traveler response to service expansion can vary widely. Ordinary service elasticities with
respect to bus miles or bus hours are in the range of +0.6 to +1.0, but elasticities greater than +1.0 and as low as +0.3 are not uncommon. The tables below (Table 5-3 to Table 5-5), which are adapted from that report, show service elasticities for various transit providers across varying time frames:

<table>
<thead>
<tr>
<th>City</th>
<th>1970 UZA Population</th>
<th>Years</th>
<th>Increase in Bus Miles</th>
<th>Increase in Ridership</th>
<th>Service Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minneapolis, MN</td>
<td>1,700,000</td>
<td>1971-1975</td>
<td>47.3%</td>
<td>39.6%</td>
<td>0.86</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>1,240,000</td>
<td>1974-1975</td>
<td>9.6%</td>
<td>8.3%</td>
<td>0.87</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>1,220,000</td>
<td>1972-1975</td>
<td>12.5%</td>
<td>10.9%</td>
<td>0.88</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>1,200,000</td>
<td>1974-1975</td>
<td>20.1%</td>
<td>13.3%</td>
<td>0.68</td>
</tr>
<tr>
<td>Portland, OR</td>
<td>1,200,000</td>
<td>1971-1975</td>
<td>42.5%</td>
<td>36.4%</td>
<td>0.88</td>
</tr>
<tr>
<td>Vancouver, BC</td>
<td>740,000</td>
<td>1971-1975</td>
<td>77.6%</td>
<td>56.8%</td>
<td>0.78</td>
</tr>
<tr>
<td>Salt Lake City, UT</td>
<td>480,000</td>
<td>1971-1975</td>
<td>117.8%</td>
<td>118.4%</td>
<td>1.00</td>
</tr>
<tr>
<td>Madison, WI</td>
<td>210,000</td>
<td>1974-1975</td>
<td>7.6%</td>
<td>8.9%</td>
<td>1.16</td>
</tr>
<tr>
<td>Bakersfield, CA</td>
<td>180,000</td>
<td>1974-1977</td>
<td>50.8%</td>
<td>49.0%</td>
<td>0.97</td>
</tr>
<tr>
<td>Raleigh, NC</td>
<td>150,000</td>
<td>1976-1977</td>
<td>28.6%</td>
<td>10.9%</td>
<td>0.41</td>
</tr>
<tr>
<td>Eugene, OR</td>
<td>140,000</td>
<td>1972-1975</td>
<td>166.5%</td>
<td>271.3%</td>
<td>1.34</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.89</td>
</tr>
</tbody>
</table>

*Asterisk denotes period including 1973-1974 gasoline shortages.*

Table 5-3: Bus Service Expansions (Short Time Frame)

<table>
<thead>
<tr>
<th>Agency (City)</th>
<th>FY1991-96 Revenue Miles Growth</th>
<th>FY1991-96 Ridership Growth</th>
<th>Service Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami-Dade Transit</td>
<td>9.37%</td>
<td>8.63%</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Table 5-4: Service Expansion (Medium Time Frame)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>1977</th>
<th>1997</th>
<th>Change or Elasticity</th>
<th>1977</th>
<th>1997</th>
<th>Change or Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td>606,000</td>
<td>8,974,000</td>
<td>+1381%</td>
<td>657,000</td>
<td>1,408,000</td>
<td>+114%</td>
</tr>
<tr>
<td>Miles</td>
<td>15,600</td>
<td>45,890</td>
<td>+194%</td>
<td>15,600</td>
<td>45,890</td>
<td>+194%</td>
</tr>
<tr>
<td>Unlinked Bus Passenger Trips</td>
<td>966,000</td>
<td>17,433,000</td>
<td>+1705%</td>
<td>1,224,000</td>
<td>1,653,000</td>
<td>+35%</td>
</tr>
<tr>
<td>Elasticity</td>
<td>+1.07</td>
<td></td>
<td></td>
<td>+1.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population</td>
<td>581,000</td>
<td>828,000</td>
<td>+42%</td>
<td>544,000</td>
<td>933,000</td>
<td>+72%</td>
</tr>
<tr>
<td>Employment</td>
<td>268,000</td>
<td>477,000</td>
<td>+78%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elasticity (Passengers Per Capita)</td>
<td></td>
<td>+0.94</td>
<td></td>
<td></td>
<td></td>
<td>+1.02</td>
</tr>
</tbody>
</table>

Table 5-5: Bus Service Expansion (Long Time Frame)

In general, larger metropolitan areas - which usually have better levels of coverage - show smaller customer response (lower elasticity) than smaller metropolitan areas. In addition, changes in service frequency alone tend to result in lower elasticities (closer to +0.5), while extensions to underserved areas and introductions of express services have more elastic responses. Given the age and existing coverage of Chicago's network, a conservative initial estimation for the value of service elasticity is in order. The experience of San Diego - a service elasticity with respect to bus miles of +0.68 - is near the bottom of the range of experiences considered here and seems appropriate.

However, we also expect that off-peak service elasticity will be higher than that for peak service, as off-peak riders generally have more flexibility in their travel behavior (departure time, destination, etc.). One study of service changes in 30 British cities found off-peak service elasticities of +0.76 on average, while peak-hour elasticities were 25% lower, averaging only +0.58. Such a relationship seems reasonable for Chicago as well, though we should not discount the possibility that targeted increases on particular peak service (e.g. lakeshore express routes) might have a more elastic customer response.

Finally, we consider elasticities for rail rapid transit. The opportunities for service improvement on rail are much more limited than those for bus, and generally consist of fare changes and minor schedule or frequency modifications. Therefore, there is much less experience to draw on when estimating customer response. Overall, we expect customer response to rail transit to be more inelastic than for bus - initial service levels are already higher, and comparable options may be less available. One study of London found rail transit service elasticities to be approximately half those of bus, which is generally the finding for fare
elasticities across rail and bus as well. In the absence of stronger information, we will use this result, but it will be important to test the sensitivity of the model on this point.

The inability of rail transit to offer service improvements is especially true during the peak period, when rail systems in large, older cities are likely to be operating at or near their safe capacity limits. Only massive infrastructure investments are able to have a significant impact on rail capacity, and Chicago is currently undertaking two New Start capital projects which will ultimately do that. The rehabilitation of the Douglas Blue Line branch will eliminate a number of slow zones, which will allow increased service, and the expansion of the Brown Line stations to accommodate eight-car (rather than six-car) trains will increase carrying capacity without a noticeable increase in operating cost. However, these projects are already well underway, and while a number of additional rail expansion projects have been mooted (extensions for a number of lines, the proposed Circle Line, etc.), they are many years away and beyond the scope of this investigation.

5.3.4 Operating Costs

In 2002, the CTA incurred heavy rail operating expenses of $359 million and motorbus operating expenses of $560 million, as shown in Table 5-6. For this model, we can divide these figures into variable costs of operation and maintenance, which fluctuate directly with service output, and fixed costs of non-vehicle maintenance and general administration, which will be roughly constant in response to service changes.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Revenue Miles (000)</th>
<th>Variable Vehicle Costs (000)</th>
<th>Non-Vehicle Maint. &amp; Admin (000)</th>
<th>Total (000)</th>
<th>Variable Cost/RVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Rail</td>
<td>61,532.7</td>
<td>$154,820.9</td>
<td>$52,540.9</td>
<td>$151,660.5</td>
<td>$359,022.2</td>
</tr>
<tr>
<td>Motorbus</td>
<td>65,901.1</td>
<td>$336,280.5</td>
<td>$115,705.5</td>
<td>$107,697.6</td>
<td>$559,683.7</td>
</tr>
</tbody>
</table>

Table 5-6: 2002 CTA Operating Costs

A more detailed cost model which analyzed specific cost drivers and created separate variable cost estimates across network components (e.g., accounting for the higher average labor cost of adding bus trips during the peak) would be required for an agency planning

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21 Operations staff at the CTA indicated in discussions that the Red and Brown Line elevated trains (the two most heavily used lines in Chicago), are operating at maximum train throughput during the peak and often face passenger load levels at or above capacity.
model. We assume, however, that for a comprehensive service expansion as proposed here, a constant-returns-to-scale production is available, and thus a system-wide cost average is sufficient for the model. We also assume that the expansion can be modeled equally well by revenue miles or revenue hours, and we choose to use revenue miles. From these assumptions, we see that each additional revenue vehicle mile on the bus network will cost the CTA $6.86, while each additional rail revenue mile will cost $3.37. Again, it will be important to test the sensitivity of these assumptions.

5.3.5 Vehicle Fleet Size and Cost

The CTA reported 1,719 bus vehicles during its maximum (peak) service period during 2003. If peak hour revenue miles are to be increased, absent significant operational changes, then additional buses will have to be purchased. The cost of purchasing a new bus varies widely depending on the size, propulsion, special features (e.g. graffiti-resistant windows), and number of buses purchased. A CTA press release from January of 2000 indicates that the average new purchase price of standard transit buses (regular diesel engine, 40-foot, air-conditioned, low-floor) under a competitively bid contract with Nova BUS Inc. was $239,000. We assume that each new bus required to achieve the policy objectives will cost $250,000.

The CTA operated 1,020 rail transit vehicles during maximum service in 2003. However, as with the peak hour capacity constraint on the rail network, the ability of the CTA to simply purchase incremental rail transit vehicles is heavily constrained. In 2004, a request for proposal (RFP) will be released and bids will be solicited for new AC-powered rail transit cars. However, these cars would not even start being delivered until 2008. In short, the amount of additional peak hour rail service which is likely to be added to the CTA network is minimal. For the sake of preliminary modeling, we will estimate the cost of an additional rail transit car to be $800,000.

5.3.6 Average Fare Revenue

Average farebox revenue per trip in Chicago was relatively constant from 2000 to 2003, staying tightly within a range of $0.82 to $0.84 as compared to the non-discounted standard fare of $1.50. This takes into account transfers, the discounts offered to certain groups of travelers, and the purchase of passes by frequent users. With the recently implemented fare changes

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22 As noted in Chapter Two, revenue seat-miles would be the preferred measure if it were readily available, but nearly all data are given in revenue hours or revenue miles.
(standard fare raised to $1.75 and transfers reduced to $0.25), the projected average fare in 2004 rises to $0.87. We assume for simplicity that this will remain essentially unchanged in response to the comprehensive service expansion.

5.3.7 Source of Ridership

If the policy objective is simply to grow overall transit ridership, then the source of the new riders who respond to the service improvements is immaterial, though it will be important when measuring the total benefits of the investment to judge its overall worthiness. However, if we are interested in offering new service with the specific goal of removing automobile trips from the roadway, then an important assumption is the fraction of new transit trips which are drawn from the auto and the fraction which are new motorized trips (either shift from walking or entirely new). The experience in this regard varies widely, but in his paper on evaluating transit subsidies in Chicago, Savage notes that ridership surveys found that 51.7% of new transit trips on the Orange Line following its opening were originally automobile trips. Following Savage, we will assume that 50% of new transit trips generated in the model are mode shifters from the auto.

In addition, most transit data sources deal in unlinked passenger trips – that is, counting each instance a passenger gets on a different transit vehicle as a new trip. This over-counts the number of actual origin-to-destination trips in the network, since many passengers must transfer as part of their transit journey. (This is one of the major service advantages of the automobile, and many transit agencies are attempting to redistribute service in order to provide “one seat rides” for as many passengers as possible.) The CTA, with its grid network and high number of bus riders, is an especially transfer-dependent system. Market research by the agency indicates that approximately 50% of passengers transfer as part of their trip. Thus, we will estimate that every three new unlinked trips generated on the network represent two origin-destination trips.

5.4 Cost Estimates

We now consider the three potential policy objectives outlined above. Before undertaking a detailed examination of their benefits, we want to estimate overall costs and see if the projects fit within reasonable economic and political constraints.
5.4.1 Diversion of Peak VMT Growth

The Texas Transportation Institute (TTI) estimated 2001 daily vehicle miles traveled (VMT) on highways and principal arterials in the Chicago metro area at 92.1 million miles per day. Growth in VMT has slowed somewhat from its high rate in the early 1990s, averaging approximately 1.6% annually between 1997 and 2001 and only 1.0% from 1999-2001. If we assume a continued annual growth rate of 1.0% from 2002 onward, and also assume that roughly 50% of the growth will be during the peak hour, the incremental peak daily VMT increase in 2005 will be approximately 0.47 million miles. TTI assumes average auto occupancy of 1.25 people and an average trip length of nine miles, implying a peak hour increase in daily person trips of 65,000. It is these trips which would need to be captured by public transit in order to divert peak VMT growth.

The area covered by the TTI analysis is the entire Chicago metropolitan area, which is significantly larger than the service area of CTA and includes the service areas of Pace and Metra. CTA currently carries approximately 80% of the transit trips in the region, and we assume for simplicity that the three RTA service boards would capture these new trips in the same proportion. For the CTA, that means 52,000 new auto-shift trips per day. Given the ridership source assumptions above, the CTA would need to provide sufficient new service to draw 104,000 new linked transit trips in order for half of those trips to be auto-shift. Assuming then that half of these new linked trips will require a transfer, the total number of new daily unlinked trips on the CTA would be 156,000.

When we consider that the current daily ridership of the CTA is only 1,500,000 unlinked trips, we see the challenge this seemingly plausible policy objective presents. Achieving this goal would require a ridership increase of over 10% in the first year alone. Just the physical and managerial constraints - finding sufficient vehicles and operators to support such rapid growth - are too great, to say nothing of the financial costs. These constraints are unlikely to be loosened, and we clearly must set our policy objectives somewhat lower.

This raises a larger question about using transit as a congestion mitigation strategy, a claim which is often made on its behalf. Especially in cities with rail rapid transit, most bus service is not oriented towards high demand corridors, but instead serves feeder and cross-town routes. Clearly this is not universally true, and all agencies offer some express bus services - the lakeshore express routes in Chicago are an excellent example. In general, however, buses in most metro areas create accessibility but don't act significantly on congestion reduction.
Congestion reduction comes instead from rail rapid transit and commuter rail, which tend to run in demand corridors parallel to more heavily traveled highways and major arterials.\(^{23}\)

The problem from a policy perspective, then, is that additional rail carrying capacity (either rapid transit or commuter) in the peak hour is unavailable in the near term for many metro areas, including Chicago, Boston, and Washington. Significant extra peak-hour capacity — enough to draw off a noticeable fraction of VMT from the most crowded roadways — would require huge capital investments, which are unlikely, and take many years to be delivered. This is not to claim that existing rail capacity does not reduce road congestion — certainly it is crucial during the peak hours. But the ability of public transit as currently structured — given bus network structure and rail network capacity — to deliver incremental peak-hour congestion reduction via endogenous expansion is questionable.

### 5.4.2 Ridership Recapture

A goal of slow but consistent overall ridership growth — in line with the FTA objectives — seems more plausible for a large, established property like the CTA. An objective to return to 1991 ridership levels within 10 years would require year-over-year ridership increases of approximately 1.5%. At this point in time, there are few obvious economic or social factors in Chicago — demographic shifts, changes in automobile pricing, etc. — that would drive such growth exogenously. Therefore, we will assume for simplicity that demand for transit stays relatively constant and any growth in ridership comes from endogenous improvements in the supply of transit.

Table 5-11 ("Scenario I: Constant Expansion"), given at the end of this chapter, shows the cost modeling for the first year of growth at this rate given the model assumptions described above. This version describes a "scaling up" of the current CTA network, with ridership fractions by mode and by peak/off-peak maintained at their current levels. Table 5-12 ("Scenario II: Targeted Growth") then shows a more realistic alternative strategy with a greater fraction of the investment directed at buses (resulting in 80% of the new rides coming on the bus network) and no additional service offered by peak-hour rail rapid transit.

Scenario I makes clear that scaling up the existing network is a highly unlikely strategy for the CTA. Assuming that the ridership increases would occur concurrently with the added

\(^{23}\) Thus, Metra’s proposed STAR line, which would provide suburb-to-suburb connections in western Cook and DuPage counties and would require a substantial use of regional capital funds, has unclear congestion mitigation capabilities.
service (a very strong assumption which we will relax in the following chapter), a 1.6% increase in annual ridership (7.2 million unlinked trips) would require additional operating subsidy of $20.3 million, an increase of 4.5% over 2003 RTA funding. The marginal farebox recovery ratio on this added service (the ratio of fare revenue to operating expense) would be only 24%, well below the 50% ratio required by the RTA. Moreover, the estimated capital costs associated with this strategy are simply not realistic for the CTA. The expansion of peak-hour bus service would require the purchase of approximately 55 new buses, at an estimated total cost of $13.8 million. While this is perhaps achievable, the projected 6% increase in peak-hour rail miles is implausible, both financially (requiring 65 new railcars at a cost of $52 million) and operationally.

A sensitivity analysis (Table 5-13) on two crucial variables – demand elasticity and unit costs per revenue mile – shows that this conclusion is robust even to significant changes in the parameters. For example, a 50% lower value of ridership elasticity, which may not be unreasonable for a dense network like Chicago where the service changes are likely to focus more on frequency improvement rather than new area coverage, leads to a ballooning of the required subsidy. (The estimated rail car investment, not shown here, becomes even more unrealistic.) In fact, in order to approach the required 50% recovery ratio, estimated demand elasticity would have to increase by 50% (actually becoming elastic for bus in the off-peak) and unit costs for the new service would have to fall by 25%. Clearly, a more reasonable strategy than a straight expansion of the current system must be investigated.

Scenario II presents such a strategy. With the same overall objective of a 1.6% increase in ridership, bus investment is emphasized in this scenario, with 80% of the new riders generated on bus (half in the peak and half in the off-peak) and no expansion of peak rail service. This approach requires an incremental public operating subsidy of $15.9 million. The additional rail capital costs are zero, while the proposed expansion of the bus fleet by 69 vehicles would require initial capital expenditure of $17.3 million. As with the original scenario, however, even this targeted investment fails to meet the required farebox recovery ratio, reaching only 28%. Table 5-14 shows the sensitivity of this model, and again heroic assumptions are required about both cost reduction and demand responsiveness in order to approach recovery of 50% of costs.

However, we have only so far considered the costs of the investment and not the benefits. This scenario of targeted investment, while failing to meet one of the (somewhat arbitrary)
budgetary constraints of the RTA, is certainly plausible and might provide enough benefits to be justified. We will examine the benefits of this scenario in the next chapter.

5.4.3 Reduction in Household Expenditures

Finally, rather than simply growing ridership for its own sake, we might make investments with a more explicit objective in mind. Table 5-7 below shows the 2004 estimates by AAA for the average cost of owning and operating a new car in the U.S. (The hypothetical car is a composite of three well-known American cars in various price ranges.) Of course, there are regional variations in insurance and fuel costs, but these figures provide a reasonable benchmark. Clearly, for low- and moderate-income households, auto ownership and operation can be a significant expense. According to calculations by the Department of Housing and Urban Development following the 2000 Census, a family of four in the Chicago metro area is considered low-income if their annual household income is below $30,700, and they are considered very low-income if it falls below $18,400. In the city of Chicago proper, more than one-third (37%) of the population lives in a low-income household, and more than 22% are in very low income households. An improvement in transit service which allowed these households to shift their travel behavior in order to drive their existing cars less or own fewer cars would offer great benefits to those households.

<table>
<thead>
<tr>
<th>Miles/Year</th>
<th>Annual</th>
<th>Per-Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Costs</td>
<td>$8,431</td>
<td>$0.562</td>
</tr>
<tr>
<td><strong>Fixed Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>$3,782</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>$1,603</td>
<td></td>
</tr>
<tr>
<td>Finance Charges</td>
<td>$741</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>$415</td>
<td></td>
</tr>
<tr>
<td><strong>Variable Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>$975</td>
<td>$0.065</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$915</td>
<td>$0.061</td>
</tr>
</tbody>
</table>

*Table 5-7: AAA Car Ownership Costs*

The distinction between the fixed and variable costs of auto ownership is crucial. Once an automobile has been purchased, the pure variable cost of operation is actually quite low – using the AAA figures, a five mile auto trip (the average length of a rail transit trip in Chicago) has a pure out-of-pocket operating costs of less than $0.65, well below the standard one-trip transit
fare in Chicago and most cities. The only other out-of-pocket cost which is likely to shift the behavior of a driver who already owns a car is parking.

Many studies have demonstrated that changes in parking fees can have a strong impact on traveler behavior and mode choice. Parking demand elasticities with respect to an area-wide price increase are usually in the range of -0.1 to -0.6, with -0.3 cited commonly. However, this single figure masks more complicated behavior by different classes of travelers. Shoppers and off-peak travelers are generally able to adjust the *duration* of their parking in response to a price increase, rather than shifting mode or eliminating the trip. Peak hour commuters, conversely, cannot adjust duration significantly, and so either pay the full new price or shift modes. It is this dynamic which allows public policies such as “parking cash-out” – where employers who subsidize employee parking offer a cash equivalent to those who choose to ride transit – to be successful. However, even the effect of parking taxes and price increases on transit ridership is not necessarily so strong. A TCRP review of studies in Los Angeles found that across eight cases where workplace parking pricing had been implemented, the average decline in mode share for single-occupant vehicles was a substantial 13%. However, the countervailing increase in high occupancy vehicle (HOV) mode share was 9%, with transit garnering only a three percentage point increase. (Of course, transit quality in Los Angeles would be judged by most observers to be well below that of Chicago and other large cities.)

Unfortunately, the results generated above for ridership recapture speak to the difficulty of achieving this goal by way of addition of incremental transit service. In the ‘Targeted Investment’ strategy above, the average operating expense per unlinked passenger trip generated is approximately $3.50. Consider a hypothetical auto driver who, in response to the new service, replaces her one-way auto commuting trip of six miles (which would be longer than the existing average CTA trip) with one and a half unlinked transit trips. If she continues to own the car for non-work trips, then only variable costs are being saved. The average daily operating costs for the CTA to provide her this round-trip are $10.50, while the variable automobile costs saved are only $1.50. In order for this “buy back” to make sense, the parking cost avoided must have been at least $9.00. That is, if the public policy concern is primarily to assist households with transportation expenses, it would be more effective to simply subsidize households for those expenses directly unless the parking cost avoided were greater than $9.00. Yet it is exactly those travelers who are already paying this sort of market rate for parking who
are extremely unlikely to be induced to switch to transit simply because of a modest increase in service availability.

There are hypothetically much larger gains to be had, as the ownership costs indicate, from inducing or allowing households to own fewer cars. But the ability of incremental investments in service to effect changes in auto ownership levels for existing households appears minimal if, as we have modeled above, the increased service comes predominately on the bus side and in off-peak rail on existing lines. In general, the ability of transit to influence auto ownership and property values – a redistribution of the actual or perceived benefits of the service from travelers to property owners – is generally limited to heavy or light rail infrastructure. (See, for example, Diaz 1999 for a recent summary of changes in property values following rail transit construction.) In addition, auto ownership and income are highly correlated. The journey-to-work mode share for rail rapid transit is relatively insensitive to income, and the share for commuter rail actually rises with income. But bus patronage is strongly negatively correlated with income and is dominated by riders from households with zero or one car (TCRP, Ch 10). It is simply not plausible to expect reductions in auto ownership from the types of improvements proposed above. Again, this does not mean that existing transit service does not provide significant mobility for those households who have fewer automobiles, either by choice or by necessity. Nor does it mean that small changes in auto expenditure patterns should not be counted as ancillary benefits. But it appears that we cannot choose this as a dominant public policy goal.

5.5 Fare Reductions

We have so far focused on increasing ridership and achieving public policy goals through added transit service provision. We now turn to the possibility of achieving such gains by means of fare reductions. Current political and budgetary realities in metropolitan Chicago make a fare reduction for the general ridership base fairly unlikely. (Mandated reductions for groups such as the elderly and high school students are already in place, and targeted programs such as discounts on weekend passes for tourists are much smaller and more politically palatable.) However, it is still instructive to get a rough estimate of the cost of growing ridership through fare reductions.
5.5.1 Fare Reduction Estimate

Fare elasticities for public transit are a much-investigated subject, and a survey of the literature provides a wide range of estimates. However, for this analysis, a rough figure is sufficient. The TCRP “Traveler Response...” Handbook reports that a demand elasticity of -0.25 with respect to fares is probably a reasonable estimate for a large system with both bus and heavy rail transit. This implies that fares would have to fall approximately 6.4% in order to generate the 1.6% ridership increase proposed above. This assumes that fare elasticities are relatively symmetric, which may not necessarily be the case since most empirical evidence in the transit industry comes from price increases rather than decreases. We then make two strong assumptions:

1) Fare reductions are operationally costless, both in terms of implementation and in terms of not requiring any alteration to service provision when ridership increases. This is relatively unobjectionable in the off-peak, but is unrealistic in the peak, when frequencies on high-demand routes would likely need to be increased.

2) We can directly apply the calculated fare reduction percentage to the ‘average fare per unlinked trip’ measure. This is unlikely to be exactly the case, as Chapter Four demonstrated, since increases in base fares are often accompanied by off-setting changes in transfer or monthly pass prices, and passengers can also modify their purchasing behavior in response to fare changes.

Using these very broad assumptions and assuming that ridership on the network simply “scales up,” we find that a first year ridership increase of 1.6% would require additional public subsidy of approximately $19.3 million to make up for the loss in farebox revenue. (See Table 5-8.) This is coincidentally quite close to the operating funding required in Scenario I above, and it requires no capital funding. But it is unrealistic in not recognizing that peak service needs will increase if service standards are to be maintained, and also that ridership response is generally more inelastic in the peak.
Estimate of overall fare elasticity in system w/ significant rail: -0.25
Desired ridership increase: 1.6%
Required fare decrease: -6.4%
Current average fare: $0.87
Required fare: $0.81

Previous riders: 452,000,000
Previous fare revenue: $393,240,000
New riders: 459,232,000
New fare revenue: $373,961,802
Subsidy shortfall: $19,278,198

Table 5-8: Systemwide Fare Reduction

The Victoria Transport Policy Institute reports that the fare elasticities in Table 5-9 were determined for transit service in Chicago. We can use these estimates to model the cost of an off-peak fare discount as a tool for increasing ridership. If we further assume that the cross-elasticity between peak and off-peak ridership is relatively low at +0.1, then we can make an estimate of the off-peak discount required to generate an overall ridership growth of 1.6%.

<table>
<thead>
<tr>
<th>Mode/Period Fare Elasticities</th>
<th>Bus</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>-0.30</td>
<td>-0.10</td>
</tr>
<tr>
<td>Off-Peak</td>
<td>-0.46</td>
<td>-0.46</td>
</tr>
<tr>
<td>Assumed peak to off-peak cross-elasticity</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-9: Chicago Fare Elasticities (from VTPI)

As Table 5-10 shows, an off-peak fare reduction of 10% would be slightly more than sufficient - this would reduce peak ridership by 1.0% but generate a 4.6% increase in off-peak patronage. In order to make up the lost farebox revenue, a public subsidy of $13.9 million would be required. This situation can more plausibly claim to have no capital costs associated with it, and in fact would have a side benefit of modestly reducing crowding during peak periods. This is an intriguing finding, but it has two problems. First, ridership increases solely in the off-peak are unlikely to provide as many regional benefits, as we will see in the following chapter. Second, the CTA has strongly resisted differential peak and off-peak pricing (as is found in Washington, DC). Nonetheless, an off-peak discount could be a more cost-effective way to achieve a one-time increase in ridership, if recovery ratio constraints and fare policies were relaxed. It might particularly make sense if an overall fare increase is required.
<table>
<thead>
<tr>
<th></th>
<th>Bus</th>
<th>Rail</th>
<th>Total</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Ridership</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>144,640,000</td>
<td>72,320,000</td>
<td>216,960,000</td>
<td></td>
</tr>
<tr>
<td>Off-Peak</td>
<td>156,693,333</td>
<td>78,346,667</td>
<td>235,040,000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>301,333,333</td>
<td>150,666,667</td>
<td>452,000,000</td>
<td></td>
</tr>
<tr>
<td>Assumed Revenue</td>
<td></td>
<td></td>
<td>$393,240,000</td>
<td></td>
</tr>
<tr>
<td>Ridership Response to Fare Reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>-0.010</td>
<td>-0.010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-Peak</td>
<td>0.046</td>
<td>0.046</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridership Increase/Decrease</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>(1,446,400)</td>
<td>(723,200)</td>
<td>(2,169,600)</td>
<td>-1.0%</td>
</tr>
<tr>
<td>Off-Peak</td>
<td>7,207,893</td>
<td>3,603,947</td>
<td>10,811,840</td>
<td>4.6%</td>
</tr>
<tr>
<td>Total</td>
<td>5,761,493</td>
<td>2,880,747</td>
<td>8,642,240</td>
<td>1.9%</td>
</tr>
<tr>
<td>Average Fare</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>$0.87</td>
<td>$0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-Peak</td>
<td>$0.78</td>
<td>$0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue Following Fare Reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>$124,578,432</td>
<td>$62,289,216</td>
<td>$186,867,648</td>
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</tr>
<tr>
<td>Off-Peak</td>
<td>$128,334,660</td>
<td>$64,167,330</td>
<td>$192,501,991</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$252,913,092</td>
<td>$126,456,546</td>
<td>$379,369,639</td>
<td>-3.5%</td>
</tr>
<tr>
<td>Revenue Differential</td>
<td></td>
<td></td>
<td>$13,870,361</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-10: Off-Peak Fare Reduction

5.6 Conclusion

Given the constraints of the public funding system and the difficulties in drawing large numbers of new riders to an existing system, the goal of modest ridership recapture through increased service provision and/or off-peak fare reductions appears reasonable for the CTA. However, we have also seen there are at least two constraints – the mandated recovery ratio and the CTA's aversion to mode- or time-specific fares – that may be preventing positive strategies from being pursued. We now turn in Chapter Six to an examination of the possible benefits from the investments and expenditures described in this chapter, and also a more detailed examination of the possible time evolution of such a project.
<table>
<thead>
<tr>
<th><strong>Goal: Annual Percent Increase</strong></th>
<th>1.6%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Bus Mode Share</strong></td>
<td>67%</td>
</tr>
<tr>
<td><strong>Share of New Trips By Bus</strong></td>
<td>67%</td>
</tr>
<tr>
<td><strong>Annual % Increase in Bus Ridership</strong></td>
<td>1.60%</td>
</tr>
<tr>
<td><strong>Current Fraction of Bus Trips in the Peak</strong></td>
<td>48%</td>
</tr>
<tr>
<td><strong>Share of New Bus Trips During Peak</strong></td>
<td>48%</td>
</tr>
<tr>
<td><strong>Off-Peak Bus Ridership Increase</strong></td>
<td>1.60%</td>
</tr>
<tr>
<td><strong>Peak Bus Ridership Increase</strong></td>
<td>1.60%</td>
</tr>
<tr>
<td><strong>Bus Peak-to-Base Ratio</strong></td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Fraction of RVM During Peak Hours</strong></td>
<td>49%</td>
</tr>
<tr>
<td><strong>Current Rail Mode Share</strong></td>
<td>33%</td>
</tr>
<tr>
<td><strong>Share of New Trips By Rail</strong></td>
<td>33%</td>
</tr>
<tr>
<td><strong>Annual % Increase in Rail Ridership</strong></td>
<td>1.60%</td>
</tr>
<tr>
<td><strong>Current Fraction of Rail Trips in the Peak</strong></td>
<td>48%</td>
</tr>
<tr>
<td><strong>Share of New Rail Trips During Peak</strong></td>
<td>48%</td>
</tr>
<tr>
<td><strong>Off-Peak Rail Ridership Increase</strong></td>
<td>1.60%</td>
</tr>
<tr>
<td><strong>Peak Rail Ridership Increase</strong></td>
<td>1.60%</td>
</tr>
<tr>
<td><strong>Rail Peak-to-Base Ratio</strong></td>
<td>2.3</td>
</tr>
<tr>
<td><strong>Fraction of RCM During Peak Hours</strong></td>
<td>53%</td>
</tr>
</tbody>
</table>

### Off-Peak
- **Off-Peak Elasticity w.r.t. Bus Miles**: 0.68
- **Annual Increase in Off-Peak Bus RVM**: 2.4%
- **Current Total Bus RVM**: 68,000,000
- **Off-Peak Bus RVM**: 34,871,795
- **Year 1 Incremental Off-Peak Bus RVM**: 820,513
- **Operating Cost Per Bus RVM**: $7.21

**Year 1 Off-Peak Bus Operating Expense**: $5,913,672

### Peak
- **Peak Elasticity w.r.t. Bus Miles**: 0.5
- **Annual Increase in Peak Bus RVM**: 3.2%
- **Current Total Bus RVM**: 68,000,000
- **Peak Bus RVM**: 33,128,205
- **Year 1 Incremental Peak Bus RVM**: 1,060,103
- **Operating Cost Per Bus RVM**: $7.21

**Year 1 Peak Bus Operating Expense**: $7,640,464

### Capital Cost for Year 1 Bus Expansion: $13,750,000

### Year 1 Ridership Increase: 7,232,000
### Average Fare Per Trip: $0.87
### Year 1 Revenue Generated: $6,291,840
### Year 1 Operating Expense: $26,588,868
### Required Year 1 Operating Subsidy: $20,297,028
### Marginal Recovery Ratio: 24%

Table 5-11: Scenario I - "Constant Expansion"
### Current Bus Mode Share
- **Share of New Trips By Bus**: 80%
- **Annual % Increase in Bus Ridership**: 1.92%

### Current Rail Mode Share
- **Share of New Trips By Rail**: 20%
- **Annual % Increase in Rail Ridership**: 0.96%

### Current Fraction of Bus Trips in the Peak
- **Share of New Rail Trips During Peak**: 50%
- **Off-Peak Bus Ridership Increase**: 1.85%
- **Peak Bus Ridership Increase**: 2.00%

### Current Fraction of Rail Trips in the Peak
- **Share of New Rail Trips During Peak**: 48%
- **Off-Peak Rail Ridership Increase**: 0.00%
- **Peak Rail Ridership Increase**: 0.00%

### Bus Peak-to-Base Ratio
- **Fraction of RVM During Peak Hours**: 49%

### Off-Peak Elasticity w.r.t. Bus Miles
- **Annual Increase in Off-Peak Bus RVM**: 0.68

### Off-Peak Elasticity w.r.t Car Miles
- **Annual Increase in Off-Peak Rail RCM**: 0.34

### Off-Peak Elasticity w.r.t Car Miles
- **Annual Increase in Off-Peak Rail RCM**: 5.4%

### Off-Peak Elasticity w.r.t. Bus Miles
- **Annual Increase in Off-Peak Rail RCM**: 35,011,628

### Off-Peak Elasticity w.r.t Car Miles
- **Annual Increase in Off-Peak Rail RCM**: 1,656,740

### Operating Cost Per Bus RVM
- **Operating Cost Per Bus RVM**: $7.21

### Operating Cost Per Rail RCM
- **Operating Cost Per Rail RCM**: $3.54

### Year 1 Off-Peak Bus Operating Expense
- **$6,823,467**

### Year 1 Off-Peak Rail Operating Expense
- **$5,865,864**

### Peak Elasticity w.r.t. Bus Miles
- **Peak Elasticity w.r.t. Bus Miles**: 0.5

### Peak Elasticity w.r.t Car Miles
- **Peak Elasticity w.r.t Car Miles**: 0.25

### Annual Increase in Peak Bus RVM
- **Annual Increase in Peak Bus RVM**: 4.0%

### Annual Increase in Peak Rail RCM
- **Annual Increase in Peak Rail RCM**: 0.0%

### Current Total Bus RVM
- **Current Total Bus RVM**: 68,000,000

### Current Total Rail RCM
- **Current Total Rail RCM**: 65,600,000

### Off-Peak Bus RVM
- **Off-Peak Bus RVM**: 34,871,795

### Off-Peak Rail RCM
- **Off-Peak Rail RCM**: 30,511,628

### Year 1 Incremental Off-Peak Bus RVM
- **Year 1 Incremental Off-Peak Bus RVM**: 946,746

### Year 1 Incremental Off-Peak Rail RCM
- **Year 1 Incremental Off-Peak Rail RCM**: 1,656,740

### Operating Cost Per Bus RVM
- **Operating Cost Per Bus RVM**: $7.21

### Operating Cost Per Rail RCM
- **Operating Cost Per Rail RCM**: $3.54

### Year 1 Peak Bus Operating Expense
- **$9,550,580**

### Year 1 Peak Rail Operating Expense
- **$0**

### Peak Bus RVM
- **Peak Bus RVM**: 33,128,205

### Peak Rail RCM
- **Peak Rail RCM**: 35,088,372

### Year 1 Incremental Peak Bus RVM
- **Year 1 Incremental Peak Bus RVM**: 1,325,128

### Year 1 Incremental Peak Rail RCM
- **Year 1 Incremental Peak Rail RCM**: 0

### Operating Cost Per Bus RVM
- **Operating Cost Per Bus RVM**: $7.21

### Operating Cost Per Rail RCM
- **Operating Cost Per Rail RCM**: $3.54

### Vehicles Operated in Maximum Service
- **Vehicles Operated in Maximum Service**: 1,719

### Vehicles Operated in Maximum Service
- **Vehicles Operated in Maximum Service**: 1,020

### Additional Peak Vehicles Required
- **Additional Peak Vehicles Required**: 69

### Additional Peak Vehicles Required
- **Additional Peak Vehicles Required**: 0

### Cost of New Bus
- **Cost of New Bus**: $250,000

### Cost of New Rail Vehicle
- **Cost of New Rail Vehicle**: $800,000

### Capital Cost for Year 1 Bus Expansion
- **$17,250,000**

### Capital Cost for Year 1 Rail Expansion
- **$0**

### Year 1 Ridership Increase
- **Year 1 Ridership Increase**: 7,232,000

### Average Fare Per Trip
- **Average Fare Per Trip**: $0.87

### Year 1 Revenue Generated
- **Year 1 Revenue Generated**: $6,291,840

### Year 1 Operating Expense
- **Year 1 Operating Expense**: $22,239,911

### Required Year 1 Operating Subsidy
- **Required Year 1 Operating Subsidy**: $15,948,071

### Marginal Recovery Ratio
- **Marginal Recovery Ratio**: 28%

---

**Table 5-12: Scenario II - "Targeted Investment"**
### Table 5-13: Sensitivity Analysis of Scenario I

<table>
<thead>
<tr>
<th>Description</th>
<th>Year 1 Operating Subsidy (000)</th>
<th>Marginal Recovery Ratio</th>
<th>Year 1 Bus Capital Expenditure (000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>$20,297,028</td>
<td>23.7%</td>
<td>$13,750,000</td>
</tr>
<tr>
<td>Demand Elasticities</td>
<td>Increase by 50%</td>
<td>$11,434,072</td>
<td>35.5%</td>
</tr>
<tr>
<td></td>
<td>Decrease by 50%</td>
<td>$46,885,895</td>
<td>11.8%</td>
</tr>
<tr>
<td>Unit Costs ($/RVM)</td>
<td>Increase by 25%</td>
<td>$26,944,244</td>
<td>18.9%</td>
</tr>
<tr>
<td></td>
<td>Decrease by 25%</td>
<td>$13,649,811</td>
<td>31.6%</td>
</tr>
<tr>
<td>&quot;Best Case&quot;</td>
<td>Elasticity Increase: 50% and Unit Cost Decrease: 25%</td>
<td>$7,002,594</td>
<td>47.3%</td>
</tr>
</tbody>
</table>

### Table 5-14: Sensitivity Analysis of Scenario II

<table>
<thead>
<tr>
<th>Description</th>
<th>Year 1 Operating Subsidy (000)</th>
<th>Marginal Recovery Ratio</th>
<th>Year 1 Bus Capital Expenditure (000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>$15,948,071</td>
<td>28.3%</td>
<td>$17,250,000</td>
</tr>
<tr>
<td>Demand Elasticities</td>
<td>Increase by 50%</td>
<td>$8,534,768</td>
<td>42.4%</td>
</tr>
<tr>
<td></td>
<td>Decrease by 50%</td>
<td>$38,187,983</td>
<td>14.1%</td>
</tr>
<tr>
<td>Unit Costs ($/RVM)</td>
<td>Increase by 25%</td>
<td>$21,508,049</td>
<td>22.6%</td>
</tr>
<tr>
<td></td>
<td>Decrease by 25%</td>
<td>$10,388,093</td>
<td>37.7%</td>
</tr>
<tr>
<td>&quot;Best Case&quot;</td>
<td>Elasticity Increase: 25% and Unit Cost Decrease: 25%</td>
<td>$7,052,107</td>
<td>47.2%</td>
</tr>
</tbody>
</table>
6 Ridership Growth II: Benefits

In Chapter Five, we identified a number of possible policy objectives as a justification for "buying back" transit ridership. However, even a simple static analysis of one-period costs made it clear that programs aimed at VMT reduction or reduction of household transportation expenditures are likely to be very difficult to achieve given current travel patterns and the costs associated with providing additional vehicle miles. However, a more limited goal of incremental (above-baseline) ridership growth has more reasonable cost requirements in the first year and is a candidate for a more extensive analysis of its benefits.

We concentrate in Chapter Six on evaluating the benefits that flow from the incremental ridership our additional public funding has created. The universe of benefits is large, and encompasses both direct benefits to transit riders and indirect benefits to travelers on other modes and even non-travelers in the region. However, as in Chapter Four, we are concerned with benefits in the three major categories that drive political decision-making: transit rider mobility, congestion mitigation, and air quality.

6.1 Estimation of Benefits

In Chapter Four, we assessed a situation where an increase in funding would mitigate the need for fare increases and prevent a shift of transit riders towards the automobile, causing increased regional VMT. Here, the additional funding serves to draw riders away from the automobile, reducing VMT from its baseline, and also improves the mobility of existing transit riders.

6.1.1 Reduced Vehicle Miles

The "Targeted Investment" scenario described in Chapter Five envisions an annual increase (over baseline) in transit trips of 7.2 million. Table 6-1, using previous assumptions regarding mode share and trip length, shows that this is likely to result in a reduction in vehicle miles traveled of approximately 48,000 per day. In a region the size of Chicago, this reduction is quite small, amounting to a reduction of only .05%.
6.1.2 Congestion Mitigation

Because the change in automobile VMT is relatively small under the "Targeted Investment" strategy, the impact on congestion mitigation is also modest. In addition, unlike in the baseline scenario, we are proposing additional service provision, so we must also account for the incremental bus vehicle miles that are being added to the roads (mostly on principal arterials) in Chicago. Due to their size and slow acceleration, we assume (for congestion modeling) that each bus mile traveled is equivalent to three automobile miles traveled. Thus, the addition of over two million annual bus revenue miles approximately halves the congestion benefits that arise from the targeted investment. Table 6-2 shows an estimation of the value of such mitigation in 2005. While it is slightly positive, it is doubtful, given the uncertainty associated with such modeling, that we can say with confidence that the benefits are significantly different from zero.

<table>
<thead>
<tr>
<th>Increase in Unlinked Transit Trips</th>
<th>7,232,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Unlinked Trips Per Linked O-D Trip</td>
<td>1.5</td>
</tr>
<tr>
<td>Increase in Linked Transit Trips</td>
<td>4,821,333</td>
</tr>
<tr>
<td>Fraction of Trips Shifting From Incremental Auto</td>
<td>50%</td>
</tr>
<tr>
<td>Reduced Auto Trips</td>
<td>2,410,667</td>
</tr>
<tr>
<td>Days Per Year*</td>
<td>250</td>
</tr>
<tr>
<td>Reduced Daily Auto Trips</td>
<td>9,643</td>
</tr>
<tr>
<td>Average Trip Length (mi.)</td>
<td>5</td>
</tr>
<tr>
<td>Incremental Daily VMT Change</td>
<td>-48,213</td>
</tr>
<tr>
<td>Original Projected Daily Highway and Principal Arterial VMT in Chicago Region</td>
<td>95,840,000</td>
</tr>
<tr>
<td>Incremental VMT Change</td>
<td>-0.05%</td>
</tr>
</tbody>
</table>

* Assume all trip shifts occur on standard work days.
6.1.3 Air Quality Improvements

As with congestion, the air quality benefits that accompany the increased ridership from the targeted investment are reduced because of the additional bus miles that are required. McCubbin and Delucchi (see Chapter Three) estimate that the average heavy duty diesel vehicle (such as a standard transit bus) has health costs due to particulate matter that are nearly ten times greater than the average gasoline vehicle. Thus, the projected twelve million mile reduction in automobile VMT is offset by the 2.2 million increase in diesel bus VMT (see Table 6-3). Again, we cannot say with confidence that the combination of the increased transit provision and reduced automobile usage will have a significant positive or negative effect. However, a move to "clean diesel" fuel or buses powered by compressed natural gas (CNG) might provide a way to mitigate some of the negative effects of increased bus service.

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected highway/arterial VMT (000)</td>
<td>94,891</td>
<td>95,840</td>
</tr>
<tr>
<td>Congestion cost (2001)</td>
<td>$4,359.6</td>
<td>$4,452.2</td>
</tr>
<tr>
<td>Change in auto VMT from baseline</td>
<td>(48,213)</td>
<td></td>
</tr>
<tr>
<td>Change in bus VMT</td>
<td>9,087</td>
<td></td>
</tr>
<tr>
<td>Auto equivalent (×3)</td>
<td>27,262</td>
<td></td>
</tr>
<tr>
<td>New proj highway/arterial VMT (000)</td>
<td>95,819</td>
<td></td>
</tr>
<tr>
<td>New congestion cost (2001)</td>
<td>$4,450.1</td>
<td></td>
</tr>
<tr>
<td>Change in congestion cost (2001)</td>
<td>($2.0)</td>
<td></td>
</tr>
<tr>
<td>Change in congestion cost (2004)</td>
<td>($2.1)</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-2: Congestion Mitigation Benefits

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in automobile VMT</td>
<td>(12,053,333)</td>
<td></td>
</tr>
<tr>
<td>Estimated Average Improvement Over 1990 Levels</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Change in Auto Pollution Costs</td>
<td>($5,599,682)</td>
<td></td>
</tr>
<tr>
<td>Change in bus VMT</td>
<td>2,271,874</td>
<td></td>
</tr>
<tr>
<td>Estimated Average Improvement Over 1990 Levels</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Change in Bus Pollution Costs</td>
<td>$7,372,204</td>
<td></td>
</tr>
<tr>
<td>Net Change in Pollution Costs</td>
<td>$1,772,523</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-3: Air Quality Impacts

6.1.4 Transit Rider Benefits

The majority of the benefits from increased service provision accrue to existing and new transit riders. Table 6-4 and Table 6-5 below show calculations for the estimated benefits. We
assume that there is no reduction in in-vehicle travel time for rail transit, and that any reductions in in-vehicle travel time for bus (which might occur because time spent per bus trip for boarding and alighting of passengers is reduced) are negligible. (Moreover, out-of-vehicle time is generally perceived by riders to be more costly than waiting time, often by a factor of two.) Thus, the benefits to riders come from increased frequency of service across the network. On busy routes, there could also be benefits in improved comfort level (e.g., greater likelihood of getting a seat), but we have omitted those benefits in this estimation. Combining the results from these two tables, we estimate total benefits to existing riders of approximately $21.2 million. Using the 'rule of one-half' (assuming a linear demand curve), we then estimate additional benefits to those new riders of $0.2 million, for a total of $21.4 million.

<table>
<thead>
<tr>
<th>Original Ridership</th>
<th>Peak</th>
<th>Off-Peak</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>144,639,840</td>
<td>156,693,160</td>
<td>301,333,000</td>
</tr>
<tr>
<td>Rail</td>
<td>72,320,160</td>
<td>78,346,840</td>
<td>150,667,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage Increase</th>
<th>Peak</th>
<th>Off-Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>2.00%</td>
<td>1.85%</td>
</tr>
<tr>
<td>Rail</td>
<td>0.00%</td>
<td>1.85%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ridership Gains</th>
<th>Peak</th>
<th>Off-Peak</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>2,892,797</td>
<td>2,892,797</td>
<td>5,786,000</td>
</tr>
<tr>
<td>Rail</td>
<td>0</td>
<td>1,446,403</td>
<td>1,446,000</td>
</tr>
</tbody>
</table>

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>7,232,000</td>
</tr>
</tbody>
</table>

Table 6-4: Ridership Changes by Mode and Period

These benefits are clearly significant for transit riders, yet they are somewhat lower than might have been expected. This is because Chicago already possesses a transit system with relatively good frequency, though of course not as high as in the past (especially for buses). That is, as headways decrease, a given percentage improvement in the headway brings a smaller per-minute benefit to the rider. We have also modeled these improvements as being spread equally across the network. In reality, some routes would probably see no changes while other routes would see greater investment. On low-frequency routes, the improvements in frequency would bring greater waiting time benefits, while on very high-demand routes, improvements in comfort might be a result. For a strategic evaluation such as this, however, we believe this provides a good order-of-magnitude estimation.
Assumed average hourly wage $19.00 (from BLS 2003 for Chicago PMSA)
Wage rate per minute $0.32

<table>
<thead>
<tr>
<th>Peak Benefits</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bus</strong></td>
<td><strong>Rail</strong></td>
</tr>
<tr>
<td>Increase in bus vehicle miles (%)</td>
<td>4.0%</td>
</tr>
<tr>
<td>Implied reduction in headway (%)</td>
<td>3.8%</td>
</tr>
<tr>
<td>Average peak headway (min)</td>
<td>7.5</td>
</tr>
<tr>
<td>Waiting time saved (reduction times one-half headway)</td>
<td>0.14</td>
</tr>
<tr>
<td>Valuation of waiting time (% of wage rate)</td>
<td>100%</td>
</tr>
<tr>
<td>Per-rider benefit</td>
<td>$0.046</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Off-Peak Benefits</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bus</strong></td>
<td><strong>Rail</strong></td>
</tr>
<tr>
<td>Increase in bus vehicle miles (%)</td>
<td>2.7%</td>
</tr>
<tr>
<td>Implied reduction in headway (%)</td>
<td>2.6%</td>
</tr>
<tr>
<td>Average off-peak headway (min)</td>
<td>15</td>
</tr>
<tr>
<td>Waiting time saved (reduction times one-half headway)</td>
<td>0.20</td>
</tr>
<tr>
<td>Valuation of waiting time (% of wage rate)</td>
<td>100%</td>
</tr>
<tr>
<td>Per-rider benefit</td>
<td>$0.063</td>
</tr>
</tbody>
</table>

Table 6-5: Benefits of Increased Service Provision

6.1.5 Summation

When we combine the congestion, air quality, and mobility benefits of the targeted investment, we find a total one-year benefit of approximately $21.8 million accruing to riders and the region. Returning to the cost estimation results in Chapter Five, we found that the “Targeted Investment” scenario required an increased annual public operating subsidy of $15.9 million, as well as an initial capital investment (for buses) of $17.3 million. However, we cannot simply sum all these costs and benefits (along with the cost of public funding) and use that to make a policy judgment. This would fail to account for potential time lags in behavior, and it would also ignore the valuable multi-period aspects of a capital asset such as a bus. In the next section, we take these results and apply them more realistically across a multi-period timeframe.
6.2 Multi-Period Evaluation

6.2.1 Changes to the Model

Rather than a simplistic one year scenario, we now expand the horizon of our analysis to five years. We will model an effort by the CTA to expand service starting in 2005 in order to raise ridership by 1.6% and then maintain that added ridership through 2009. This will allow us to make two key changes to the analysis.

First, it is unrealistic to assume that the benefits which accompany an increase in service provision will occur immediately (i.e., within the period when the new service is started). A number of factors may be at work here, for both riders and the agency. It takes time for knowledge of the changes to filter through to the riding public, and then additional time for those riders to respond and change their trip-making behavior. At the agency level, the CTA will have to spend operating funds to hire and train new drivers and to modify timetables and/or routes prior to putting the new service on the road. For existing riders, we will assume that 75% of their benefits are realized in the first year and that the full measure is realized in the second and following years. This same 75% time lag factor will therefore apply to the congestion and air quality dis-benefits that accompany the additional bus service. Benefits to new riders, as well as the positive effects of changes in automobile VMT, are assumed to ramp up at a slower rate as new riders are attracted to the service. We assume that only 50% of those benefits are realized in the first year, and the full amount is realized in all following years. These assumptions will have a dampening effect on the net value of the investment scenario.

Second, the long-lived nature of a capital asset such as a bus must be recognized. Given the bonding capability of the RTA and the State of Illinois, it is reasonable to suggest that the bus purchase could be financed through borrowing and then paid off over the life of the vehicle. Therefore, we model a scenario where the buses are financed at a 5% rate over a ten year vehicle lifetime with equal payments in each period. (For the sake of conservatism, this is a somewhat higher rate than current five-year A-rated municipal bonds.) At the end of the five year analysis period, we have two options for dealing with the buses, which still have both significant value to the CTA and financing to be covered. If the value of the ridership generation is negative, we assume that project can be “cancelled” and that the buses can be shifted to other parts of the system to replace older buses already scheduled for retirement and replacement. If the value of the ridership generation is positive, then we continue charging the bus costs to this project, and
calculate a terminal value for continuing the incremental service an additional five years until the end of the bus life.

6.2.2 Results

Using the same assumptions as above, and assuming that real operating costs and revenues remain constant, the expected net benefits are modestly negative for this service expansion. Table 6-6 shows the net present value calculation for the five-year time horizon, assuming a discount rate of 7% as discussed in Chapter Three. The slow ramp-up of ridership benefits causes large negative net benefits in the first year, and then the relatively high operating subsidy (and the additional inefficiency loss due to public funding) results in slightly negative net benefits even in the "out" years. The total NPV is approximately –$12.2 million.

<table>
<thead>
<tr>
<th>(all figures in millions)</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Subsidy</td>
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<td>$15.9</td>
<td>$15.9</td>
<td>$15.9</td>
<td>$15.9</td>
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<td>$4.7</td>
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<td>$22.9</td>
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<tr>
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<td>$21.8</td>
<td>$21.8</td>
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<td>($1.1)</td>
<td>($1.1)</td>
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<td>Discounted Value</td>
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<td>($1.0)</td>
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<td>($0.9)</td>
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Table 6-6: Multi-Period Costs and Benefits of Expansion

However, the previous analysis assumes that the average auto trip removed from the system had a length of five miles. Table 6-7 below shows a brief sensitivity analysis on that variable. If the CTA were able, through skillful provision of the increased service, to draw slightly longer trips into the system, then the net value of this service expansion appears to be approximately break-even. Since we have attempted to be conservative in estimating the benefits of the expansion, such an expansion could at least be seriously argued in the public arena.
Moreover, the possibility of reduced operating costs holds the key to this service expansion. If we are able to reduce unit operating costs by 25%, as shown in the sensitivity analysis of Chapter Five, then the expected NPV of the expansion project becomes strongly positive at $33.7 million (Table 6-8). The net benefits are still negative in the first year, but become positive in all of the out years. Moreover, there are additional benefits to be gained by continuing to use the new buses on this incremental service improvement for a second five years.

<table>
<thead>
<tr>
<th>Average Length of Shifted Trip (mi)</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Terminal</th>
</tr>
</thead>
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<tr>
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<td>$3.3</td>
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<tr>
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<td></td>
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<tr>
<td>Consumer Benefits</td>
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<td>$21.8</td>
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<td>Net Benefits</td>
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<td>$25.8</td>
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</tr>
<tr>
<td>NPV</td>
<td>$33.7</td>
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<td></td>
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</tbody>
</table>

Table 6-8: Multi-Period Costs and Benefits (25% Unit Cost Reduction)

If this level of cost reduction can be achieved, then the benefits of this expansion will be robust even to the shifts in average trip length described above. As Table 6-9 shows, even if the CTA were to draw predominately very short trips into the system with its new service, the lower cost structure makes this a justifiable project.

<table>
<thead>
<tr>
<th>Average Length of Shifted Trip (mi)</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Terminal</th>
</tr>
</thead>
<tbody>
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<tr>
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<tr>
<td>Public Funds Cost</td>
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</tr>
<tr>
<td>Total Costs</td>
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<td>$15.9</td>
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<tr>
<td>Consumer Benefits</td>
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<tr>
<td>Net Benefits</td>
<td>($2.2 )</td>
<td>$5.9</td>
<td>$5.9</td>
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<td>$5.9</td>
<td>$25.8</td>
</tr>
<tr>
<td>Discounted Value</td>
<td>($2.1 )</td>
<td>$5.1</td>
<td>$4.8</td>
<td>$4.5</td>
<td>$4.2</td>
<td>$17.2</td>
</tr>
<tr>
<td>NPV</td>
<td>$33.7</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 6-9: NPV (in millions) of Targeted Expansion (Five Years Plus Terminal Value)
6.3 Conclusion

Benefits to current users dominate in the targeted expansion scenario, though there are congestion mitigation benefits, and net air quality benefits would likely exist if CNG or clean diesel buses were used. Using a net present value analysis over a five year time horizon, we find that the expected result of the expansion would have slightly negative net benefits to Chicago, although the result is essentially break-even if the CTA can draw longer trips into the system. In addition, if the CTA’s internal measures of performance could improve, then sizable external benefits of such an expansion could be realized. If significant – but not unreasonable – cost reductions could be implemented on the new service, then the expansion would show robustly positive net benefits. We discuss the policy implications of this result in the final chapter.
7 Conclusions and Future Research

After assessing the past and present environment for transit in Chicago and determining a framework for modeling potential changes to public transportation funding within that environment, we analyzed the costs and benefits of (1) maintaining baseline ridership on the CTA and (2) achieving incremental growth in ridership. Now, we want to summarize the policy implications from those analyses and also describe future areas of research that need to be explored in order to expand on the work in this thesis.

7.1 Review of Findings and Policy Recommendations

The policy recommendations arising from this analysis are summarized in three areas – dealing with the immediate future, generating additional ridership, and considering changes to the fare structure.

7.1.1 Immediate Future

The analysis in Chapter Four indicates strongly that the RTA and the State of Illinois should not allow the CTA to fall into a financial crisis by rigidly following policy constraints and leaving current funding structures unchanged. Historical experience shows that ridership loss is likely to be high, and the costs of this crisis – in both lost ridership and reduced mobility for existing riders – are significantly larger than the additional funding needed to avoid it.

Raising the additional public subsidy via taxation is, in principle, a straightforward political problem, though of course it would encounter serious opposition in some quarters. However, one other significant policy constraint will also need to be changed. Such a direct infusion of funding in order to simply maintain fares and ridership would violate the 50% farebox recovery ratio requirement, despite its positive net benefits. As noted earlier, this constraint was a well-intentioned effort at guaranteeing cost-efficiency at the CTA, but it is now having perverse effects by enforcing a downward spiral of fare increases and service cuts. As part of a larger political package (which should include dealing actively with growing paratransit expenditures), the mandated recovery ratio should be reduced or eliminated. This recommendation applies to all the scenarios described here. (See next section on ‘Future Research’ for a follow-up.)
7.1.2 Ridership Generation

While the analysis for "holding the line" in the near term is clear-cut, the prospects for increasing ridership through agency action in the future are slightly more ambiguous. As the discussion in Chapter Five showed, larger societal goals such as diversion of incremental VMT growth into transit are extremely optimistic given the size of the Chicago region. A more limited strategy of slowly increasing ridership back to previous levels, however, appears initially promising. And yet the net benefits of a service expansion - even one targeted at buses and off-peak ridership - are slightly below break-even, given the high unit costs of the CTA as described in Chapter Six.

Yet the analysis does indicate a number of opportunities for changes that might turn an expansion into a net positive project. A minor one is the introduction of “clean diesel” fuel or CNG-powered buses, as the positive impacts of reduced auto VMT are currently mitigated by the particulate emissions of a standard diesel transit bus. A somewhat larger opportunity comes through the source of taxation used to fund the expansion. The cost of public funds associated with a sales tax is relatively large. If the expansion were funded through a tax on a less elastic transportation good, such as vehicle registration or a parking tax, the public costs would be lower and the net benefits of the expansion would be greater. Looking further into the future, funding through a congestion charge (as has recently been implemented in London) would introduce the least distortion of all, to say nothing of the significant benefits such a change could have on congestion costs.

The greatest opportunity lies in reducing operating expenses, as shown in Chapter Six. A 25% reduction in cost per revenue mile turns the targeted expansion into a significantly positive project, and one which is robust even to variability in average trip length. Since the major operating cost factor is (highly unionized) labor, such a change would require political skill and a willingness to make fairly radical changes. The likelihood of achieving wage reductions across the labor force, given the federal 13(c) labor protections and the political strength of the unions in Chicago, is minimal. However, if the choice is presented as being between no expansion (or even slow contraction) and a job-creating expansion with different contract terms for the new drivers, then it might find acceptance. In practice, this would likely involve the contracting out of some low-demand routes to an independent operator with a lower wage structure, and then a redeployment of the existing vehicles and drivers to the rest of the network.
7.1.3 Fare Structure

We explored the possibility of changes to the fare structure in order to capture ridership in Chapter Five. If the agency is simply interested in increasing ridership, then an off-peak fare discount may actually be a more financially feasible approach, since it requires a lower operating subsidy and no capital expenditures. Though we did not investigate it here, there is also the option to differentiate fares according to mode, as is done in Boston and other cities. The move at Chicago, as at many agencies, towards multifunction "smart cards" makes implementation of such fare structure changes much simpler. In addition, by inducing some marginal peak riders to shift into the shoulders of the peak, the capacity of the system is better utilized and room opens up for future growth in peak ridership.

However, there are practicalities that argue against fare changes as a method for increasing ridership. First, the CTA has long had a policy in favor of fare simplicity and against differentiation by mode or period. Second, the policy arguments for simultaneously loosening the recovery ratio and reducing standard fares will be difficult to sell to many constituencies in Illinois. Finally, and most importantly, fare changes and reductions are good for one-time ridership boosts, but they will lose their potency rather quickly. That is, it is difficult to continually ratchet down fares in order to grow ridership. Service expansion, conversely, could continue in year-over-year fashion as long as the expected discounted benefits of each expansion were positive.

At the time of the completion of this thesis (June 2004), awareness of the financial crisis at CTA is growing in both the Illinois state legislature and in the general public. It appears possible that the CTA will receive some financial relief, but it will likely be insufficient to both maintain fares and increase service. This might be an opportune moment, politically, to introduce the concept of fare differentiation. A likely combination, for example, would put a higher fare on peak-hour rail service, and the lowest fare on off-peak or weekend bus service. Extra revenue generated from this pricing scheme could then potentially be used to increase service provision. However, a straightforward combination of the results from scenarios described here would not be correct, as joint changes in fares and service would make the consumer elasticity response more complicated to model.

7.2 Future Research

In this thesis, a number of research areas have been touched on, but require further study. We highlight here three of the most interesting.
7.2.1 Asymmetry of Rider Response

We have not explored deeply into the complex consumer behavior inherent in the decision by a person or household to purchase an automobile. The cost structure of the automobile – with high fixed or upfront costs and low marginal costs – creates a strong asymmetry in traveler behavior vis-à-vis transit. As the CTA was losing 30% of its riders since the late 1970s in response to declining service and increasing fares, many of these lost riders purchased automobiles. And once the initial expenditure on that auto was made, the ability of the CTA to recapture these riders – even by returning to previous levels of service quality and price – was severely reduced.

Future research should examine this asymmetry more closely, with particular focus on two areas. First, households do eventually have to replace automobiles. Especially for older households whose children have grown or persons purposely choosing to move into dense, transit-friendly neighborhoods, a study of the “threshold factors” for deciding not to purchase another car and shift back to transit would be valuable. Second, the nascent “car-sharing” movement (with firms such as Zipcar, Inc., which operates in Boston, Washington, and New York) now has a number of years of experience and data on which to draw. One of the explicit goals of car-sharing is to allow people to purchase car services on a more purely marginal basis. A study of car-sharing users’ behavior – with regard to transit, shared cars, taxis, and other forms of transportation – could also provide constructive insights.

7.2.2 Local Goods and Multiplier Benefits

As noted earlier, the expenditures that households make on automobiles go predominately to firms outside their region, and even outside the country. Transit operating expenditures, Conversely, go mostly towards labor, which is centered within the local economy. We have not included any estimate of a multiplier effect of this shift in regional spending in response to an increase in transit service provision. In the scenarios described here, we expect the impact to be relatively small, since the ridership generated is also small. But for larger projects that have been proposed for Chicago, such as the Circle Line, this impact could be significant, and research into these effects will be useful in justifying such investments.

7.2.3 Performance-Based Funding

Previous suggestions at the CTA regarding performance-based funding mechanisms have been given a relatively cool reception. However, while this thesis is proposing a relaxation or
even elimination of the recovery ratio requirement, we also recognize the need for external controls or incentives in order to enforce cost efficiency at the agency. Instead of a recovery ratio, a funding mechanism at the RTA or state level that guaranteed a baseline level of funding to the CTA (and Metra and Pace) and then offered additional discretionary monies in response to demonstrated improvements in internal measures of service effectiveness might convince legislators that a relaxation of the recovery ratio would not mean a return to the high labor wage growth of the 1970s. Further study would be required to construct a set of indicators that would simultaneously be meaningful, easy to understand, and robust to manipulation.
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