Public Transit and the Time-Based Fare Structure

Examining the Merits of Peak Pricing for Transit

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About the Research Institute

Established in 1979, The Urban Transportation Center at The University of Illinois at Chicago conducts research, provides education, and delivers technical assistance on urban transportation planning, policy, operations and management. The institute specializes in three research clusters: (1) disadvantaged populations and human sustainability; (2) Intelligent Transportation Systems; and (3) public transportation, highways and freight planning, operations and management. The highly interdisciplinary center is composed of faculty, staff, and student researchers with expertise in urban planning, civil engineering, business administration, economics, public administration and computer science.

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Table of Contents

Executive Summary

This report examines the merits of a time-based fare structure for public transit. The report is divided into three main sections. The literature review summarizes academic research on the benefits and costs of peak pricing. The next section features case studies of five major systems that use peak pricing. The final section compares academic research to case study findings, and offers a decision-making framework to those considering a peak pricing strategy.

Public transit primarily serves professionals during peak hours for the work-related trip. Transit authorities incur disproportionately high capital and labor costs to accommodate peak service demand for only a few hours each day. Transit managers struggle to contain labor costs. During the off-peak, much of the fleet sits idle, lowering revenue productivity. One major study found that peak-period bus costs were 59% greater than base-period bus costs. Flat fares fail to proportionately address the higher costs of peak service.

Research suggests that peak pricing has three major benefits. First, it can enhance service effectiveness by attracting new off-peak ridership without expanding capacity or significantly increasing operating costs. Second, peak pricing can improve social equity by reducing the financial burden on low-income riders who take a relatively high proportion of off-peak trips. Third, peak pricing can increase cost efficiency by generating more revenue through higher peak fares. Further, travel pattern shifts, in response to peak pricing, can lower capital and operating costs, and relieve strained capacity.

Case study analyses support the assertion that peak pricing enhances service effectiveness and improves social equity. However, the case studies produced little data on the relationship between peak pricing and cost efficiency. None of the five case study agencies has rigorously examined how peak pricing impacts their ridership, revenue, and costs. Previous research efforts demonstrate that it is very difficult to isolate the effect of price on ridership. Service frequency and on-time performance are more likely to influence ridership than fare price. None of the featured agencies use a cost allocation model that accurately measures how costs vary by mode, distance, time, direction, or vehicle-passenger capacity.

The exact design of a time-based fare structure will vary based on agency priorities. However, all time-based fare structures should be expansive enough to include all customer groups and should restrict the use of unlimited ride passes, which promote over-use when service costs are highest. Further, peak pricing should be one piece of a regional transportation policy that encourages flexible work schedules and congestion pricing on urban freeways.

Transit agencies will face challenges to implementation, but many are not new: the uncertainty of how riders will respond to the price change; the risk of fare evasion (using off-peak tickets in the peak at barrier-free systems); customer disputes with operators as to the appropriate fare charge; and the cost of new technology to support the fare structure. The biggest key to success will be raising consumer awareness of the rationale for peak pricing, convincing key interest groups that the agency is well-managed, and securing strong political leadership to make the new fare structure a reality.

INTRODUCTION

This report summarizes the author's research on the benefits and costs of a time-based fare structure for domestic transit systems. Transit authorities, using this type of fare structure, charge a higher fare during peak travel times, when operational costs are greatest. In this country, peak periods are most commonly associated with the work-related commute in the early morning and late afternoon of each workday. Key benefits and costs of so-called "peak pricing" are listed below.

Benefits

- Increase cost efficiency: generate more revenue; lower service costs
- Enhance service effectiveness: attract new off-peak ridership
- Improve social equity: reduce financial burden on low-income riders

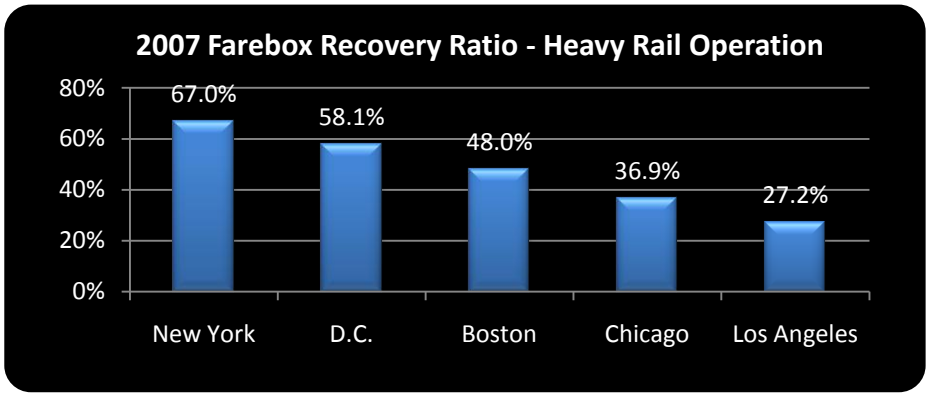
Costs

- More difficult to market: low consumer awareness of differentiated fares
- Increased chance of customer disputes with operator as to proper fare
- New technology to display/charge correct fare based on time-of-day

Background

Many U.S. transit agencies are required by their charter to generate enough fare revenue to cover a specified percentage of operational cost. This ratio between passenger revenue and operating expenses is sometimes referred to as the farebox recovery ratio (American Public Transportation Association, 2003). In some cases, the ratio is limited to passenger revenue collected from fare media such as cash, tickets, passes, and fare cards. In other cases, the ratio accounts for other system-generated revenue, such as advertising, charter services and concessions. Farebox recovery ratios tend to vary by system, depending on its size, primary mode, stated policies, and the ratio calculation itself. Figure 1 provides farebox recovery ratios for the 5 largest transit agencies in the country (Federal Transit Administration [FTA], 2007). The ratio only accounts for revenue collected from fare media, and is limited to each agency's heavy rail operation.

Figure 1



Transit agencies face increasing pressure to do more with less. Local legislators and the general public seek expanded and enhanced service but are hesitant to pay for it. Over the past few decades, the level of public subsidy has not kept pace with rising costs. Like many public organizations, transit agencies allocate a relatively large percentage of their budget to pay for labor expenses. Combined, the top 5 agencies spend 82% of their operating budget on wages, salaries, and benefits (FTA, 2007).

Especially during economic downturns, transit authorities often struggle to balance their budget because they have less flexibility than private firms to manage their labor costs. Even in years of declining tax revenue, an agency's contract with its unionized labor force may dictate that it provides annual wage increases and expansive layoff protection. Thus, authorities must find other ways to reduce costs. Otherwise, they will need to raise fares to reach the required farebox recovery ratio. At the same time, agencies must address political pressure to hold fast to their mission, which often includes an explicit commitment to serve the community by offering regular service at low prices.

Transit authorities are very hesitant to raise fares. They fear that higher prices will reduce ridership, which will translate into reduced service to reflect the lower demand. Decreased service may further erode ridership, necessitating higher fares to cover the budget gap. This can lead to a downward spiral of fare increases followed by reduced service. Many riders, who leave transit after a fare increase, are lured back into their cars. Historically, private auto travel has been under-priced. Consumers have not had to pay the full costs of driving on congested freeways, such as pollution, delays, and accident-related costs (Fielding, 1995). As the result of an inefficient pricing structure, freeways are over-used, while transit, which is less price competitive, is under-used. When developing fare policy, transit authorities must address consumer demand for high quality service at affordable prices, while adjusting for competition from private travel on urban freeways.

Research suggests that a time-based fare structure offers the potential to generate more fare revenue, to increase off-peak ridership, and to reduce the financial burden on low-income riders (Transit Cooperative Research Program [TCRP] 2004; Luhrsen and Taylor, 1997).

Research Scope

The primary focus of this research was to explain the potential benefits and costs of a time-based fare structure for domestic transit systems. The first step was to examine the theoretical arguments for and against peak pricing. In this report, the literature review summarizes academic research by leading scholars on the key advantages and disadvantages of peak pricing. The next step was to study those U.S. systems that use peak pricing, and to understand how their experience compares to academic studies. In the United States, 5 of the 20 largest transit authorities use some form of peak pricing. These are as follows:

- Port Authority of Allegheny County (Pittsburgh, PA)
- Southeastern Pennsylvania Transportation Authority (Philadelphia, PA)
- Metro Transit (Minneapolis / St. Paul, MN)
- King County Metro Transit (Seattle, WA)
- Washington Metropolitan Area Transit Authority (Washington D.C.)

King County Metro Transit and Metro Transit use peak pricing throughout their network. Washington Metropolitan Area Transit Authority and Port Authority of Allegheny County use peak pricing on rail, but not on bus. Southeastern Pennsylvania Transportation Authority limits peak pricing to its intercity regional rail system.

This report contains individual case studies of each of the aforementioned authorities. These studies are primarily based upon structured interviews with agency personnel, agency-produced quantitative information, and a comprehensive review of external and internal documents. Because of the variation in the type and depth of information, the structure of each case study is somewhat unique.

Unfortunately, none of the transit agencies has rigorously studied how peak pricing has impacted their ridership and revenue. This may be due to several reasons:

- IT systems do not provide the type of quantitative information needed
- No cost allocation model that reflects cost variability by time period
- Difficult to isolate price effect on ridership
- Peak pricing implemented for reasons other than cost efficiency
- Limited resources to dedicate to fare structure evaluation

A final step in this research was to discuss how case study findings can direct future policy decisions on peak pricing. This report includes a section that uses academic research and case study findings to build a decision-making framework

to help transit organizations understand if a time-based fare structure can effectively support agency goals[1].

Data Sources

The author submitted the same data request to each agency. A copy of the request can be found in Appendix 1. This request addressed the following areas:

- Trip purpose and distance by time of day
- Ridership patterns by socioeconomic status, gender, race, etc.
- Rider demographics by mode; comparison to all metro households
- Elasticity studies (price elasticity, income elasticity, cross elasticity)
- Frequency of transfer trips by time of day
- Ridership figures by mode, time-of-day, and fare media
- Revenue figures by mode, time-of-day, and fare media

Appendix 2 summarizes the type of information collected from each transit agency. Primary data sources included:

- Federal Transit Administration (National Transit Database)
- Annual budget documents
- Customer surveys
- Local newspaper articles
- Fare charts
- Ridership figures
- Audits of operational performance
- Agency website content
- Agency interviews

As for internal documents, most agencies were able to provide customer survey data and ridership figures. Less information was available on trip distance, fare media usage, and elasticity studies. In most cases, the planning department managed ridership while the finance department handled revenue. Due in part to this separation of responsibility, the author did not receive any integrated reporting to show how fare policy impacted ridership and revenue. Further, none of the 5 transit agencies has migrated from a flat-fare to a time-based fare structure in the last 10 years. Thus, they could not provide any data to show how the initial switch to peak pricing impacted ridership patterns and revenue collection.

Key contact information for each case study is provided in Appendix 3. These contacts include officials from the transit authority as well as the local metropolitan planning organization.

[1] Due to time constraints and a lack of information, this report does not evaluate how different transfer policies may impact ridership and revenue.

LITERATURE REVIEW

This section summarizes past academic research related to the study of a time-based fare structure for transit.

Public Policies have Driven Shift from Public Transit to Private Auto
Over the past fifty years, an increasing number of Americans, especially those who vote, prefer self-reliant policies, which support their desire to achieve the "affluent lifestyle", rather than policies that relate to fairness, equality, and the public good. Government officials, recognizing these desires, have instituted policies that facilitate the shift from public transit to private auto. Because of public subsidies, highways are under-priced, encouraging consumers to use them for every type of trip (Yankelovich, 1994). In densely-packed cities, commuter rail and bus rapid transit, which enjoy exclusive right-of-way and limited stops, have successfully competed with private auto for work-related trips. However, the vast majority of cities have witnessed a consistent decline in transit ridership over the second half of the last century. Economists contend that only when motorists pay the full cost of driving on congested highways will a significant portion alter their travel behavior.

Most transit agencies experience a persistent tension between equity and administration. Many transit planners advocate for a differentiated pricing structure that supports goals related to cost efficiency, service effectiveness and social equity. Riders pay based on the amount of service consumed, the cost of providing the service, or the quality of the service received. However, many in the board room push for a flat-fare structure because it is easier to understand and cheaper to administer (TCRP, 1996). Additionally, it offers more protection from fare abuse and it is better suited to market-based pricing strategies.

Many Transit Agencies Use a Variety of Differentiated Pricing Strategies
Figure 2 shows the mostly commonly used differentiated pricing strategies by the twenty largest U.S. transit agencies. Figure 2 illustrates that each agency incorporates at least one strategy into their fare structure. The most common strategies are as follows:

1. **Time-Based (or Peak Pricing)**
    - Distinct fares for "peak" v. "off-peak" times
    - Customers pay a higher fare for the peak trip (when demand is greatest)

2. **Distance-Based (or Zonal Pricing)**
    - Fares determined based on distance traveled or zones entered
    - Customers pay a higher fare when traveling greater distances and/or across more pricing zones

3. **Service-Based**
    - Distinct fares by mode (rail v. bus) or by speed (local v. express service)
    - Customers pay a higher fare when benefiting from higher service levels (frequency, in-transit time) with rail and/or express service

4. **Market-Based**
    - Fares differ depending on the type of fare media used
    - Customers who pay greater upfront costs for unlimited ride passes (weekly, monthly, annual pass) receive the greatest price discount
    - Customers who use stored value cards often receive a discounted fare per trip

Figure 2

Fare Pricing Strategies - As of November 2006					
Transit Agency	City	Market-Based	Time-Based	Distance-Based	Service-Based
MTA New York City Transit	New York City	X			
Chicago Transit Authority	Chicago	X			
WMATA	Washington D.C.	X	X	X	X
Los Angeles County MTA	Los Angeles	X			
Massachusetts Bay TA	Boston	X		X	X
Southeastern Pennsylvania TA	Philadelphia	X	X		
San Francisco Municipal Railway	San Francisco	X			
MARTA	Atlanta	X			
Maryland Transit Administration	Baltimore	X			X
King County Metro	Seattle	X	X	X	
Miami-Dade Transit	Miami	X			X
Tri-County MTDO	Portland	X		X	
SF Bay Area Rapid Transit District	SF/Oakland	X		X	
MTA - Harris County, Texas	Houston	X			X
Metropolitan Council	Mpls/St.Paul	X	X		X
San Diego MTS	San Diego	X		X	X
Denver Regional Trans District	Denver	X		X	X
Dallas Area Rapid Transit	Dallas	X		X	
Port Authority of Allegheny County	Pittsburgh	X	X	X	
Bi-State Development Agency	St. Louis	X			X
COUNT		20	4	9	9

Market-based pricing is a key strategy used by each of the top 20 agencies. The most popular technique of market-based pricing is deep discounting. Richard Oram (1990) explains that deep discounting is "… a strategy based on building commitment to transit use through substantial discounts on prepaid tickets or tokens. These prepaid discounts, a minimum of 25 percent of the base fare, are achieved by raising cash fares to create a significant differential between the cash and ticket (or token) price, or by reducing the ticket price … The deep discount fare strategy motivates riders to increase their usage by providing major savings on a multi-ride purchase of tickets or tokens."

Oram argued that deep discounting segments the market into 4 distinct groups, based on a consumer's frequency of use and price sensitivity. He found that riders who fall into the low usage, low sensitivity category will typically pay the

cash fare, even if it is higher than other options. In effect, they pay a surcharge for the convenience of using cash, choosing not to take advantage of savings opportunities easily available to them. At the other extreme, a second group of consumers, who are high usage and highly price sensitive, will predictably purchase discounted options, with the most frequent riders generally opting for unlimited-ride passes. A third group of consumers who are high usage, but with low price sensitivity, will tend to use some form of prepayment, for convenience if not for price. Finally, a fourth group of consumers, who are highly price sensitive, but with relatively low usage, will tend to respond to a deep discounting strategy by purchasing more rides than they would otherwise do under normal conditions. Although they are paying less per ride than they would if paying cash, they are ultimately contributing more to the farebox because they are paying for a greater number of rides than they would if not prepaying for multiple rides. This last group's response is the strongest rationale for implementing a deep discounting strategy. In this scenario, the transit agency will certainly lose revenue on the second group, but potentially gain revenue from the fourth group. A cost-effective strategy will ensure that any loss is more than off-set by revenue gains from the fourth group of highly price sensitive, low usage consumers. The first group of consumers, who continue to pay the now higher cash fare, can also contribute to total revenue gains. A well-executed deep discounting strategy has the potential to increase revenue and ridership simultaneously. Transit agencies can study consumer response to a deep discounting strategy to gain insight as to the size and price sensitivity of each consumer segment. These insights can be instructive when predicting how consumers might respond to a peak pricing strategy.

Figure 3 provides a brief overview of commonly cited advantages and disadvantages of each differentiated pricing strategy (TCRP, 1996). For comparison, the below chart includes a "flat-fare" structure, which charges customers the same fare regardless of fare media, time, distance, or service.

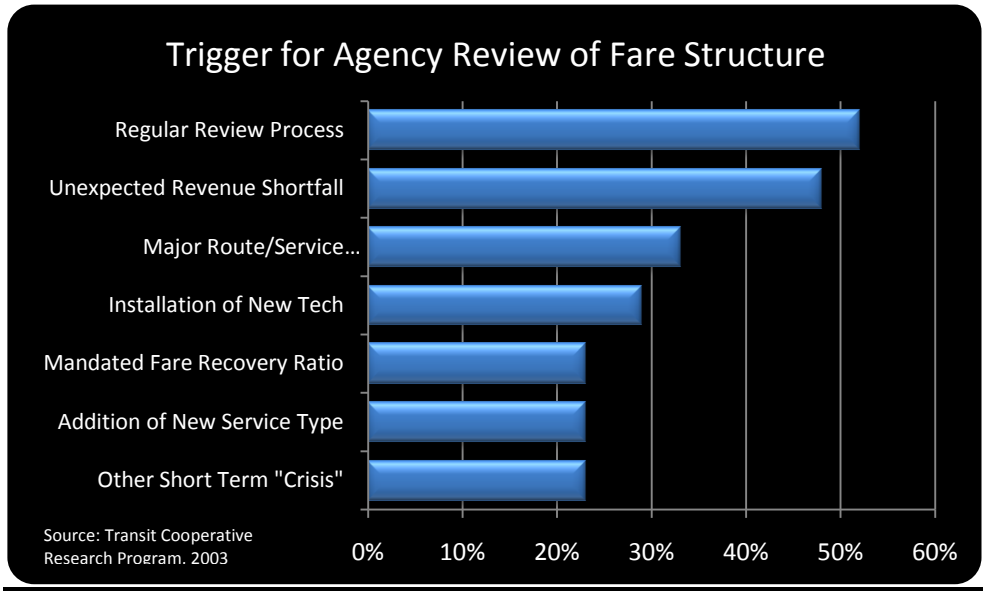
Figure 3

	Flat-Fare	Market-Based	Time-Based	Distance-Based	Service-Based
Advantages	Simplicity Cheapest cost to implement and administer Lowest level of fare abuse No scope for overriding Easy to market and understand	Builds customer loyalty Reduces handling of cash in system	Potential to increase ridership Improved use of fleet over course of day More equitable – commuters pay more	Potential to produce more revenue Equitable; longer trip carriers higher fare	Simplicity More equitable: higher quality or higher priced service has higher fare Higher revenue potential
Disadvantages	Places inequitable burden on those making shortest trips Fare increase will cause greatest loss of riders Not efficient: fare levels do not correspond to operating costs Discourages shorter-distance trips	Deep discounting makes it difficult to calculate cost per trip Greater administration costs to manage various fare media Less equitable: large cash outlay needed to purchase bulk discounts	Potential for conflicts with drivers Technological upgrades required No relationship between fare and distance traveled	Calculation of fare for irregular trips difficult Difficult to implement and administer Significant infrastructure upgrades required Transfers challenging to handle	Resistance from riders of higher cost services Transfers more complicated when upgrading to higher service

New Technologies Support Use of Differentiated Pricing Strategies

Newer technologies may diminish some of the previous advantages of a flat-fare structure. Consumers can use features on many transit websites to plan their next trip, making it relatively easy for them to understand how fare prices may vary according to mode, distance, and time-of-day. Increasingly, more transit providers are migrating from Automatic Fare Collection (AFC) systems that employ traditional fare media to the latest contactless smartcard systems. This technology offers expanded capabilities, making it more feasible to implement distance-based, time-based, and service-based pricing schemes. Despite this development, Streeting and Charles (2006) suggest that transit agencies have addressed fare policy as an afterthought, taking a technology-driven, rather than policy-driven, approach to the AFC procurement process. To support their argument, Streeting and Charles cited a 2003 study of U.S. transit systems (Figure 4) that found that the installation of new technology was the “trigger” event for a fare structure review in only 30% of cases. Over 50% of reviews were triggered by way of either a regular review process and/or an unexpected revenue shortfall.

Figure 4



Researchers continue to add to the growing body of research on the disadvantages of a flat-fare structure. Luhrsen and Taylor (1997), conducting an in-depth study of the Los Angeles Metropolitan Transportation Authority (MTA), reported a number of findings which support a policy shift away from a flat-fare structure and towards some version of a differentiated fare structure, beyond just market-based pricing tactics. They showed how differentiated fare pricing has the potential to simultaneously improve cost efficiency, service effectiveness, and social equity.

Differentiated Pricing Can Increase Cost Efficiency

Because passenger-serving costs are a function of the marginal cost of service, rider costs vary significantly by mode, time, and distance. Flat-fares fail to proportionally address the variable costs between modes or the higher costs of peak service. In many cases, a differentiated pricing structure drives up demand by lowering fares on less-expensive-to-provide service. This pricing scheme can take the form of reduced fares on buses (service-based discounts), during the off-peak (time-based discounts), and for short trips (distance-based discounts).

With service-based pricing, a transit agency would charge more for rail service because they incur higher capital costs to purchase fully or partially exclusive rights-of-way, and construct the tracks, catenary, tunnels, and stations. Further, rail riders tend to take longer-distance trips, consuming more of the service. Off-peak local bus service is generally the cheapest transit mode because capital costs are limited to the purchase of vehicles and labor costs are typically spread out over an entire day. Express service is generally more expensive than local bus because it is typically offered only during peak periods (Luhrsen and Taylor, 1997). The cross-subsidy of rider groups is reduced when the fare charged is

related to the marginal cost of providing the service. In this scenario, the relative subsidy of each passenger is roughly equal.

Differentiated Pricing Can Enhance Service Effectiveness

In a flat-fare environment, consumers are discouraged from taking shorter trips, which are cheaper to offer, because of the relatively high cost per mile. Differentiated pricing, in the form of distance-based pricing, could attract incremental short-distance riders without the need to expand transit capacity or substantially increase operating costs. Research indicates that a higher proportion of short trips are made during off-peak hours when excess capacity usually exists on most transit vehicles and capital costs are low (Cervero, 1981).

Differentiated Pricing Can Improve Social Equity

Differentiated pricing can improve the social equity of transit service. Unlike choice riders, transit dependents[2] tend to take a higher proportion of local bus trips, shorter trips, and more non-work trips, which are more likely to occur during off-peak hours. In a flat-fare structure, this relatively low-cost service is over-priced. Thus, transit dependents tend to pay more per mile of service consumed, effectively cross-subsidizing the trips of higher-income riders. Unlimited ride monthly passes encourage service consumption without regard to the marginal costs of providing the service, disproportionally benefiting higher income riders who tend to travel longer distances during peak periods. Low income riders lose out on this benefit because they lack the disposable income to purchase unlimited ride discounts and other bulk volume discounts. In the MTA study, passengers with annual household incomes above $71,700 had average trip lengths that were almost twice that of riders making less than $15,000 (2008 dollars). Differentiated pricing could minimize this cross-subsidy by aligning fare price with service cost.

Robust Cost Allocation Model Necessary for Fare Structure Design

Transit providers must account for service cost variations in order to design an effective differentiated pricing strategy and to determine the appropriate service levels. Taylor, Garret, and Iseki (2000) recommend that agencies use a robust cost allocation model that segregates expenses into variable, semi-fixed, and fixed costs, and consider only those costs that vary with service outputs over the scope and scale of the analysis. At the time of their study, they reported that few agencies used a sophisticated enough model to accurately measure how costs vary according to factors such as mode, distance, time, direction, and vehicle-passenger capacity. Further, Taylor et al. (2000) stated that many agencies did not capture capital costs in their cost allocation models, categorizing them as off-budget items because capital projects are mostly funded with state and federal dollars. However, the researchers insisted that capital expenses be captured to provide a more accurate picture, reflecting the variances by mode, and when

[2] The Federal Transit Administration defines transit dependent persons as those (1) without private transportation, (2) elderly (over age 65), (3) youths (under age 18), and (4) persons below poverty or median income levels defined by the U.S. Census Bureau.

making comparisons between publicly operated and privately contracted transit services. When Taylor et al. (2000) compared the results from a more sophisticated cost allocation model to the one used by the Los Angeles MTA, they discovered that peak period bus costs were higher; base period bus costs were lower; light rail unit costs were significantly higher than bus unit costs; and that the cost of small additions of bus service were substantially lower regardless of time of day.

Transit Riders Respond to Changes in Fare Price in Different Ways

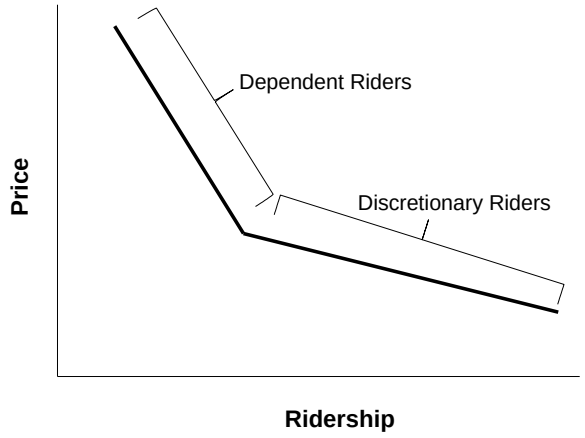
Scholars reinforce the complicated nature of forecasting traveler response to public transit. Rather than a simple buy/no buy decision, travelers must make several decisions related to trip frequency; destination choice; schedule choice; mode choice; and path choice. In the short run, price is one of the easiest ways for transit organizations to influence rider response to public transit.

Todd Litman (2006) has written extensively about how price sensitivity impacts public transit usage. He wrote about several factors that affect the price elasticity of demand for public transit. Price elasticity of demand is defined as the percentage change in quantity demanded resulting from a 1% change in price (Mansfield and Yohe, 2004). For example, a price elasticity value of -0.40 indicates that a 10% fare increase will reduce ridership by 4%. A higher absolute value signals that the consumer will more readily change their behavior in response to a price change. The following are 9 leading factors that affect price elasticity of demand for transit:

1. ***User Type****:* Transit dependent riders are generally less price sensitive than "choice riders", considered to be those who have the option of using an automobile for a particular trip. As stated previously, transit dependents typically include non-drivers, youth, elderly, disabled, and lower-income riders. In most communities, transit dependents are a relatively small portion of the total population, but a rather large portion of transit users. As illustrated in Figure 5, there is a "kink" in the demand curve between transit dependents and choice riders (Clements, 1997). Elasticity values tend to be significantly lower (less price sensitive) for the portion of the demand curve representing basic mobility by transit dependents, and higher (more price sensitive) for the portion representing travel by discretionary (choice) riders.

Figure 5

Transit Rider's Demand Curve



Price changes may have relatively little impact on ridership for a basic transit system that primarily serves transit dependent users. In this scenario, two factors may represent the best opportunity to increase the share of price-sensitive discretionary riders: (1) a significant fare decline and service improvement, or (2) private auto drivers pay a price that more accurately reflects the cost to travel on freeways. By surveying motorists, Lee, Lee and Park (2003) found that car owners are more sensitive to parking fees, travel time and crowding, than to fare prices. This finding indicates that these motorists are more likely to respond to improved transit service rather than reduced fares.

2. ***Trip Type:*** Non-commute trips tend to be more price sensitive than commute trips. Price elasticities in the off-peak are typically 1.5 to 2 times higher than peak period elasticities.

3. ***Geography:*** Riders taking trips in large cities tend to be less price sensitive than those taking trips in the suburbs or smaller cities. There may be several reasons for this: (1) greater number of transit dependents in urban areas; (2) auto travel is more convenient and less expensive in smaller cities and suburbs; (3) large cities can support higher levels of transit service to better retain riders; (4) central cities tend to offer more rail service, whose customers are less responsive than bus riders to fare changes; (5) larger cities tends to be where transit is the most price and service competitive versus private auto. Pham and Linsalata (1991) conducted a study of short-term (less than 2 years) effects of fare changes across 52 U.S. transit systems in the late 1980s. Their results, listed in Figure 6, shows that demand for transit tends to be less price elastic in larger cities as well as during peak hours.

Figure 6

	Large Cities (>1.0M population)	**Smaller Cities** (<1.0M population)
All Hours	-0.36	-0.43
Peak Hours	-0.18	-0.27
Off-Peak Hours	-0.39	-0.46

4. ***Type of Price Change:*** Transit fares, service quality (speed, frequency, coverage, comfort), and auto costs (parking fees, roadway tolls) have the greatest impact on transit ridership. An effective demand management strategy will seek to package fare reductions with increased transit service and congestion pricing to drive a migration from private auto to transit. When consumers perceive that transit fares are already "too high", they tend to be somewhat more price sensitive compared to starting from a fare level that is considered "more reasonable". Fuel price tends to have less impact; however, this theory may need to be re-evaluated in the wake of historically high fuel prices over the last two years.

5. ***Direction of Price Change:*** Contradictory evidence exists on whether to apply the same elasticity value to price increases as well as price reductions. Transportation demand models often apply the same elasticity value; however, some scholars have discovered that ridership declines from price increases tend to be greater than ridership gains from price drops. Further, they have found that when a price increase or transit strike induces a household to purchase an automobile, those trips can be lost forever since people tend to continue driving once they become accustomed to this mode choice. In contrast, limited data suggests that ridership response to fare decreases is fairly symmetrical to that of fare increases (Webster, Bly and Paulley, 1988). Figure 7 summarizes the results from a study of 23 fare changes in similarly-sized U.S. cities, which found that elasticities for fare increases were not significantly different than those for fare decreases (Mayworm, Lago, and McEnroe, 1980).

Figure 7

Fare Change	**Mean & Standard Deviation**	**Number of Cases**
Increase	-0.34 ± 0.11	14
Decrease	-0.37 ± 0.11	9

6. ***Timeframe:*** Price impacts are often categorized as short-term (typically, within one year), medium-term (within five years) and long-term (more than five years). Price elasticities increase over time, as consumers factor price changes into more decisions, such as where to live or work. For transit, long-term elasticities tend to be two or three times as large as short-term elasticities.

7. ***Distance:*** Price elasticity is higher on the very short and on the very long trips. Walking and cycling are alternatives to the short public transit trips while the car is an alternative on very long trips (Fearnley, 2004)

8. ***Transit Type:*** Figure 8 shows that price elasticities for bus and rail can differ (Paulley, Balcombe, 2004). This is for several reasons. First, Pratt (2000) reported that, in major cities, rail elasticity values tended to be lower than bus elasticity values because rail systems are more apt to serve higher-income residents who can more easily absorb fare increases. Second, customers perceive that rail provides more consumer value than bus. Because of its exclusive right-of-way, train cars do not have to compete with other vehicles on the roadways, enabling it to travel at greater speeds. Across all U.S. transit systems, the average travel speed was greatest for heavy rail (20.1 mph), followed by light rail (14.9 mph), and then finally bus (12.7 mph) (FTA, 2005). Third, many older rail systems use a radial design oriented to trips in and out of the central business district, contributing to longer distance trips, which tend to be less price sensitive. Conversely, bus systems have much shorter trips in the neighborhood, where walking and the automobile are more effective competitors. Savage (2004) reported on rail elasticities of -0.256 (average 6 mile trip) and bus elasticities of -0.457 (average 2 mile trip) at the Chicago Transit Authority. However, rail elasticities will likely be higher on suburban commuter lines that parallel freeways because customers have more viable alternatives to reach their final destination.

Figure 8

Timeframe	Rail	Bus
Short-run	-0.3	-0.4
Medium-run	N/A	-0.56
Long-run	-0.6	-1.0

9. ***Time-of-Day:*** Elasticity studies consistently show that peak trips are significantly less price sensitive than off-peak trips. In Figure 9, Litman (2006) compares peak versus off-peak elasticity values over the short-run (first year) and long-run (5-10 years).

Figure 9

	Market Segment	Short Run	Long Run
Transit ridership WRT transit fares	Overall	-0.2 to -0.5	-0.6 to -0.9
Transit ridership WRT transit fares	Peak	-0.15 to -0.3	-0.4 to -0.6
Transit ridership WRT transit fares	Off-peak	-0.3 to -0.6	-0.8 to -1.0

There are many reasons for the relatively low elasticity value for peak trips. Some of the most significant include:

- Highly correlated with work (non-discretionary trips).
- More service consumption: trips cover longer distances.
- More valuable when agencies provide greater frequency of service during peak periods. For example, average headways on Washington D.C.'s rail system vary during the peak (6 min.), midday (12 min.), Saturday (12 min.), and Sunday (15 min.) (WMATA, 2006).

While data is limited, many studies tend to suggest that fare elasticities for evening and weekend service are not substantially different from the values observed for midday service (Mayworm, et al., 1980; Fairhurst and Morris, 1975). Factors that will affect the change in off-peak ridership include the percentage reduction in the off-peak fares, the relative difference between peak and off-peak fares, and the percentage of peak riders who could conveniently shift their trip to off-peak periods.

Many Agencies Use the Simpson-Curtin Formula to Predict Future Ridership

Increasingly, transit organizations are using more sophisticated computer models to predict rider response to fare change. These models often use demographic data that is unique to an agency's customer base. However, many agencies still rely upon the Simpson-Curtin *formula* to calculate a rough forecast of transit demand. The formula, which describes a shrinkage ratio relationship rather than an elasticity relationship, was derived from a regression analysis of before-and-after results of 77 surface transit (bus and streetcar) fare changes in the 1960s (Curtin, 1968). The Simpson-Curtin formula is as follows:

$$Y = 0.80 + 0.30X$$

Where:
Y = % loss in ridership as compared to the prior (before) ridership
X = % increase in fare as compared to the prior (before) fare

Using this formula, a 10% fare increase is estimated to translate into a ridership decline of 3.8%. The formula is equivalent to a mid-point fare elasticity value of -0.39 to -0.41 for fare changes that range from 10% to 40% (TCRP, 2004).

More recently, transit managers have tended to use the Simpson-Curtin *rule*, derived from the formula of the same name. This rule states that each 3% fare increase reduces ridership by 1%. However, scholars have criticized the rule as outdated and overly simplistic because it ignores the impact of the regression constant (0.80), introducing a large estimation error for small fare changes (TCRP, 2004).

Academics have demonstrated that the multi-dimensional nature of forecasting transit demand does not lend itself to a one-size-fits-all approach like the Simpson-Curtin rule. Mayworm et al. (1980), studying the before-and-after effects of rail and bus fare changes on U.S. transit systems in the late 1970s, found a mean fare

elasticity value of -0.28 with a standard deviation of ±0.16. Thus, roughly two-thirds of the elasticity observations fall within the range of -0.12 and -0.44. Such a relatively wide range of observed elasticities has led scholars to conduct deeper analyses to understand what explanatory variables help describe the variation in rider response to fare changes.

Some research indicates that transit customers are less likely to respond to fare increases below the rate of inflation. Two English studies examined the effects of inflation and concluded that the fare elasticity of fares decreasing is the same as the elasticity of fare increases (Bly, 1976; Fairhurst and Morris, 1975). This suggests that transit systems might be able to increase fares to keep pace with inflation and not lose ridership.

Gillen (1994) evaluated transit fare elasticities by different user groups and trip types. This body of research is consistent with other findings. Based on the table below (Figure 10), those groupings that demonstrate lower price elasticity include the elderly, lower income, and transit dependents. Likewise, riders taking peak and/or work-related trips as well as those covering greater distances tend to be less price elastic.

Figure 10

Factor	Elasticity
Overall transit fares	-0.33 to -0.22
Riders < 16 years old	-0.32
Riders 17-64 years old	-0.22
Riders > 64 years old	-0.14
People earning < $5,000	-0.19
People earning > $15,000	-0.28
Car owners	-0.41
People without a car	-0.10
Work trips	-0.10 to -0.19
Shopping trips	-0.32 to -0.49
Off-peak trips	-0.11 to -0.84
Peak trips	-0.04 to -0.32
Trips < 1 mile	-0.55
Trips > 3 miles	-0.29

The following outlines additional transit-related elasticity studies.

- ***Cross-elasticity:*** Cross-elasticity refers to the changes in demand for a good that result from a change in the price of a substitute good. In transit, this exchange can take many forms. For example: (1) changes in auto travel due to transit fare changes; (2) changes in transit ridership due to changes in automobile operating costs; (3) and changes in ridership for one transit mode in response to price changes for another transit mode. Hensher (1997) surveyed the residents of Newcastle, a small Australian

city, to develop a model of elasticities and cross-elasticities between various forms of transit and car use. Figure 11, which summarizes Hensher's findings, can be used to understand how various changes in transit fares and car operating costs affect transit and car travel demand. For example, a 10% price increase in single fare train tickets translates to a 2.18% reduction in the sale of those fares, a 0.57% increase in single fare bus tickets sold, and a 1.96% increase in the number of car trips. These types of studies have relevance to peak pricing. Several transit agencies, including WMATA, use peak pricing on rail, but maintain a flat-fare structure on their bus network. Those agencies that are considering a similar design can use cross-elasticity studies to predict what percentage of their customer base might migrate from a time-based structure on rail to a flat-fare structure on bus. For any consumer that places greater value on fare price relative to in-transit or wait time, we might expect them to take the bus, rather than rail, even if it takes longer to reach their final destination.

Figure 11

	Train (Single Fare)	**Train (Ten Fare)**	**Train (Pass)**	**Bus (Single Fare)**	**Bus (Ten Fare)**	**Bus (Pass)**	**Car**
Train, single fare	-0.218	0.001	0.001	0.057	0.005	0.005	0.196
Train, ten fare	0.001	-0.093	0.001	0.001	0.001	0.006	0.092
Train, pass	0.001	0.001	-0.196	0.001	0.012	0.001	0.335
Bus, single fare	0.067	0.001	0.001	-0.357	0.001	0.001	0.116
Bus, ten fare	0.020	0.004	0.002	0.001	-0.160	0.001	0.121
Bus, pass	0.007	0.036	0.001	0.001	0.001	-0.098	0.020
Car	0.053	0.042	0.003	0.066	0.016	0.003	-0.197

Litman (2006) has summarized additional cross-elasticity studies, comparing elasticity values in the short term versus the long term. These are included in Figure 12 below:

Figure 12

	Market Segment	**Short Term**	**Long Term**
Transit ridership WRT transit service	Overall	0.50 to 0.7	0.7 to 1.1
Transit ridership WRT auto operating costs	Overall	0.05 to 0.15	0.2 to 0.4
Automobile travel WRT transit costs	Overall	0.03 to 0.1	0.15 to 0.3

The Hague Consulting Group (1999) estimated that a 10% rise in fuel prices will increase transit ridership by 1.6% in the short-run and 1.2% in the long-run. The lower elasticity value in the long-run is unique to fuel prices because motorists tend to purchase more fuel-efficient vehicles over the long-run when fuel prices steadily rise. Further, Litman (2006) reported

that parking prices (and probably road tolls) tend to have a greater impact on transit ridership than other vehicle costs, such as fuel, typically by a factor of 1.5 to 2.0, because they are paid directly on a per-trip basis.

- ***Service elasticity:*** Service elasticity refers to how much transit ridership increases (decreases) in response to an increase (reduction) in transit vehicle-mileage, vehicle-hours or frequency. The elasticity of transit use to service area expansion is typically in the range of 0.6-1.0. This means that a 10% increase in vehicle-miles or vehicle-hours will increase ridership by 6-10% (Evans, 2004). The elasticity of transit use with respect to transit service frequency (called headway elasticity) averages 0.5. Higher service elasticities often occur with (1) new express transit service, (2) in university towns, and (3) in suburbs with rail transit stations to feed. It usually takes 1 to 3 years for ridership on new routes to reach its full potential.

  Service elasticities are also affected by other variables:

  1. **Time period:** peak versus off-peak
  2. **Demographic factors:** socioeconomic profile of rider, % of population who is transit dependent
  3. **Geographic factors:** population density, employment density, pedestrian accessibility
  4. **Service quality:** speed, comfort, schedule information
  5. **Fare price**

  Transit ridership tends to be more responsive to service improvements than to fare reductions. Pratt (2000) concludes that "ridership tends to be one-third to two-thirds as responsive to a fare change as it is to an equivalent percentage change in service", and most responsive to combinations of service improvements and fare reductions. Service improvements often relate to speed, frequency, coverage, and comfort.

- ***Economic Factors:*** Kain & Liu (1999) demonstrated how certain economic indicators are correlated to increased transit ridership. Their results, found in Figure 13, show how gains in regional employment and central city population each contribute to ridership growth.

  Figure 13

Factor	Elasticity
Regional employment	0.25
Central city population	0.61
Service (transit vehicle miles)	0.71

The Metropolitan Transport Simulator (METS) is a computer-based simulation model of transit supply and demand used by officials of London, England's transit

system to conduct cost-benefit analyses, determining whether the benefits of lower fares and faster trips outweigh the cost of public subsidies. The simulation model represents London's system as a series of inter-related equations. For example, the model includes an equation that describes the demand for bus trips as a function of the cost of the journey and the cost of alternative modes such as bus, trains, subway, cars, and taxis. Figure 14 summarizes elasticities used in the METS model. The table shows how the demand for one mode changes as costs (fares and travel time) change. Each circled value is the own-price elasticity of demand. All other values are cross-price elasticities of demand. For example, a 10% increase in car costs will reduce car use by 3%. A 10% increase in bus costs will increase car use by 0.9%. A 10% increase in subway costs will increase car use by 0.57%. Based on the data, bus trips (-0.64) are more responsive to own-price changes than subway (-0.50) or car (-0.30) trips. However, note that all the own-price elasticities are between 0 and -1, which implies that total revenues should rise if fares/costs go up (Grayling and Glaister, 2000).

Figure 14

	Car	Bus	Subway
Car	-0.30	0.09	0.057
Bus	0.17	-0.64	0.13
Underground	0.056	0.20	-0.50

The complexity of a simulation model like METS comes from the need to accurately measure costs. Trip costs are not limited to the price of the bus ticket or the amount of fuel consumed by your car. A critical component in calculating trip costs is the value of a person's time, often measured relative to hourly wage rates. For transit, trip length depends on waiting and boarding times, as well as average travel speeds. Fares, waiting times and travel speeds are inter-related. For example, a bus fare reduction will increase demand for buses, reducing the demand for alternative modes, which should increase average travel speeds, since there will be fewer cars on the road, and thus, less traffic congestion. This might lead to less time to reach your final destination. However, countervailing effects could actually increase your total trip time. For instance, if bus demand is so great as to exceed capacity, you might have longer wait times, watching packed buses pass you by, until you can board a bus with empty space.

Consumer Cost Includes Fare Price, In-Transit Time, and Wait Time

Ian Savage and August Schupp (1996), economics professors at Northwestern University, examining the case for public subsidies of transit operations, suggest that each transit rider faces a generalized cost (GT) according to the below equation:

$$GT = P + w(M) + t(M, Q_t)$$

Where:
P = fare price
M = number of vehicle miles operated
Q_t = number of transit riders

The w(M) function represents the monetary equivalent of the time taken waiting at stops. The $t(M, Q_t)$ function is the monetary equivalent of time taken on the vehicle or "in-transit time". In this case, the transit agency chooses the levels of P and M, the market will determine GT and Q_t.

Waiting time (w) is taken as a function of headway (H) between bus or train arrivals at a stop. Seddon and Day (1974) noted that for headways of up to 12 minutes, passenger arrivals at stops are random and w is one-half of H. However, for longer headways, transit users attempt to arrive at stops close to the time of departure, and w becomes less than one-half H. In one study of transit systems in Washington D.C. and Los Angeles, Parry and Small (2005) reported that wait costs were 1.7 to 3.3 times as large for off-peak periods versus peak hours. This relationship is expressed in the following equation that shows w and H in seconds:

$$w = 11.39 + 0.49H - 0.00009H^2$$

Savage and Schupp report that in-transit time for bus varies according to the average load factor. Increasing passenger loads on the bus will increase in-transit time because the bus will have to stop more frequently and/or for longer periods to allow the extra people to board and alight. The change in average travel time is the number of extra people multiplied by the average boarding and alighting time (BAT). This effect is not seen on rail service because the number of stops is predetermined and station dwell time is less sensitive to changes in load factor. The researchers valued in-transit time at one-half the average wage rate, and waiting time at the average wage rate. For comparison, these researchers report that auto drivers value their time at 65% of the average wage rate on moderately congested roads, and 78% of the average wage rate on severely congested roads.

These researchers suggest that social welfare can be maximized given the following conditions:

- Fares are set equal to the delay caused to all existing riders due to the boarding and alighting of the marginal rider.
- The operating cost of a marginal vehicle mile should be set equal to the benefit to riders of the marginal vehicle mile on their waiting and in-transit time, less the revenue gained from the new passengers attracted to the improved service. This condition recognizes that while additional service will generally lower GT (less wait time), there is a countervailing effect in

that the additional passenger trips generated may slow service because of the extra boarding and alighting time.

Savage and Schupp (1996) use the conditions above to draw attention to two important implications.

1. Fares and service levels are both policy variables. Any additional subsidy can be used to reduce the fare or enhance service levels.
2. Passengers impose externalities on each other. On one hand, additional passengers increase the travel times of existing riders because of additional time spent at stops. On the other hand, exogenous increases in demand will result in the provision of additional service, and this will generate more ridership because generalized cost will fall as waiting times and the number of people on each vehicle falls. This latter economy of scale in the number of passengers on user costs is commonly referred to as the "Mohring effect".

Alternatively, Savage and Schupp argue that welfare maximization would be reached if congestion pricing were used on roadways equal to the time penalty imposed by the marginal user on all of the existing users who now have to travel slower because the road is more congested. Until this approach is more feasible and universal, they recommend using public subsidies to make transit more attractive and thereby encourage some road users to switch modes.

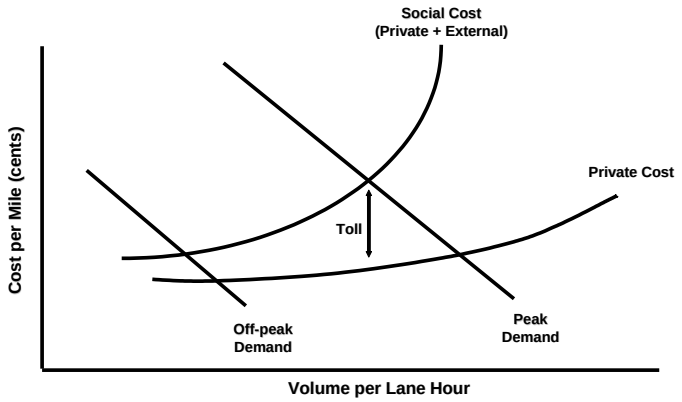
Peak Pricing on Transit is Related to Congestion Pricing on Roadways
The time-based fare structure, or so-called "peak pricing", has its roots in congestion pricing on urban freeways. During the peak, when highways are congested, every additional user creates a demand for additional space. Since lanes cannot be added in the short run, congestion occurs, causing delays for all users. Congestion pricing is based on the concept of charging user fees to cover the cost of constructing and maintaining freeways plus the external costs of driving in congestion, which include delays, noise, and air pollution (Transportation Research Board, 1994). If users were required to pay a toll representing the external costs, congestion would be reduced. In some ways, this pricing scheme is similar to utility pricing in which additional charges are levied during the peak period to discourage use. By reducing demand, the utility company may avoid the high cost of constructing additional facilities required for only a few hours each day.

In the off-peak periods, when highways are uncongested, user charges only need to cover the cost of amortizing construction and maintaining highways plus a small social cost. These tolls could make all users better off; some travelers might delay their trip until the price was lowered, others would shift to transit alternatives, and still others would pay the higher toll to enjoy a faster trip. This last group, which is willing to pay a premium to save time, would supply the revenue required to

construct additional facilities (Fielding, 1995). This concept is represented visually in Figure 15.

Figure 15

Congestion Pricing for Highways



As demand increases during the peak period, the congestion toll would increase relative to the increased negative externalities created by congested roadways. This toll will shift demand to other times and/or modes.

Source: Fielding, 1995.

Congestion pricing schemes can be divided into two main types:

- ***Cordon charges***: applies to all highways, bridges, or tunnels serving a congested area. For example, in London, England, drivers are charged a fee to enter the city center during the business day.
- ***Corridor charges:*** applies to part or all of one congested highway, bridge, or tunnel. This type can be further divided:
  - *Variably priced facilities:* all lanes of a highway, bridge, or tunnel are subject to a congestion charge.
  - *Variably priced lanes:* some lanes of a highway, bridge, or tunnel are subject to a congestion charge
  - *High-occupancy toll (HOT) lanes:* vehicles with one or two occupants (for instance) are subject to a congestion charge when using HOT lanes

Congestion Pricing on Urban Roadways Offers Several Benefits
A recent study by the Congressional Budget Office (2009) cited several key benefits of congestion pricing:

- ***Reduced congestion:*** London's cordon charge reduced congestion by 30%. Congestion was defined as the difference between actual travel times and travel times when traffic is flowing freely (Transport for London, 2003). The Port Authority of New York and New Jersey use congestion pricing on

its six bridges and tunnels. After the first year, peak morning traffic declined by 7% and peak afternoon traffic fell by 4%, while overall traffic remained the same. Studies of State Route 91 in Orange County, California have estimated that congestion charges sufficient to increase the total trip cost by 10% decrease traffic by 3.6% compared to a scenario in which the lanes had been built but not priced (Small, Winston, and Yan, 2006)[3].

- ***Shorter travel times:*** In the London example, travel speeds within the congestion zone increased by 10% to 15%, while travel times for trips entering or exiting the zone declined by 14% (Evans, Bhatt, and Turnbull, 2003). In the Orange County example, congestion pricing reduced travel time on the priced lanes by more than 8 minutes for a 10 mile trip (Small, Winston, and Yan, 2006). Because users of the priced lanes implicitly tend to value their time more than users of the unpriced lanes, as evidenced by their willingness to pay the charge in return for a faster trip, a net benefit results. The Orange County study found that pricing the lanes reduced congestion enough to generate a net savings of more than $2 per trip[4].
- ***More reliable travel times:*** In London, surveys of highway users indicated that the variability of trip times into and out of the charging zone declined by roughly 30% after implementation of the cordon charge. Data from the Orange County example found that highway users valued an improvement in the reliability of their travel time as much as they valued a decrease of similar magnitude in travel time itself[5].
- ***More efficient investment:*** Congestion pricing allows existing highway capacity to carry more traffic at the same or improved operational performance, thus reducing the need for highway investment. In a recent study, the U.S. Department of Transportation's Federal Highway Administration (2006) estimated that widespread implementation of congestion pricing could reduce the amount of investment needed to maintain the highway system at its current physical condition and operational performance by more than 25%. Congestion pricing also informs future investment. Recall that the total of all congestion fees paid on a particular highway equals the value of the delays that could be avoided if capacity were greater. Viewed that way, congestion fees represent the return on investment in increasing that highway's capacity. By helping to identify the need for new capacity at the right place and at the right time, congestion pricing can promote more efficient future investment, and it can help pay for its construction. For example, revenues from congestion pricing more than cover capital and operating expenses for the priced lanes on California State Route 91 (Orange County Transportation Authority, 2006).

[3] The total cost of a trip includes operating costs, the value of travel time, and the value of travel time reliability.
[4] Users of the priced lanes implicitly valued their time at $25.51 per hour, while users of the unpriced lanes valued their time at $18.63 per hour. The benefits accrue primarily to those who remain in the priced lanes.
[5] Users of the priced lanes implicitly valued reliability at $23.78 per hour, while users of the unpriced lanes valued reliability at $19.50 per hour.

Peaked Demand for Transit Service Creates Operational Inefficiencies

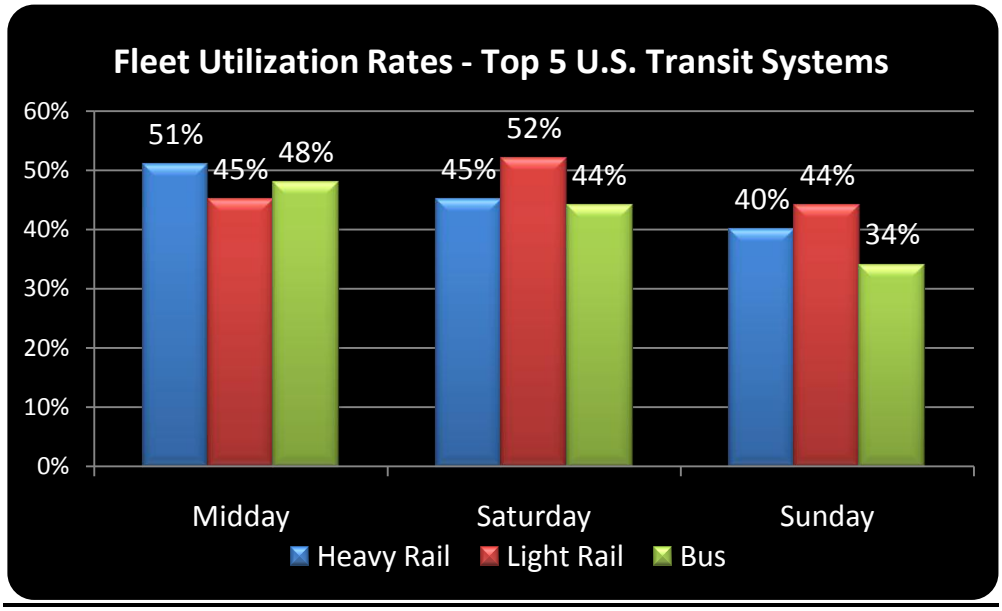
For many reasons, public transit no longer meets the needs of a wide variety of people for a wide variety of purposes. Instead, it primarily serves professionals during peak periods for the work-related trip (Saltzman, 1992). High peak service demand increases fleet costs associated with purchasing, operating, and maintaining additional vehicles needed only for peak service. Because of these fleet costs, and the need for additional peak-demand operators, peak trips are much more expensive to offer than off-peak trips (Cervero & Wachs, 1982). Transit systems with high peak-to-base operations are significantly more costly than systems with a more consistent level of operations throughout the day. Depending on the type of system, peak-base ratios range from 1.5 to 4. At the mean value, doubling the peak-base ratio while holding car hours constant increases short-run variable costs by 21% (Savage, 1997). This cost disadvantage would be compounded when allowance is made for the capital costs of the additional cars that are used in the peak only. Figure 16 provides additional perspective as to how peak-base ratios vary by system type (Savage, 1997).

Figure 16

	Streetcar	New Light Rail	Traditional Light Rail	New Commuter Heavy Rail	New Heavy Rail	Traditional Heavy Rail
Peak-Base Ratio	1.7	1.9	2.6	4.5	2.7	2.2
City Example	New Orleans	San Diego	SF MUNI	SF BART	Wash D.C.	Chicago

During the off-peak period, ridership is relatively low, idling much of the fleet, reducing its revenue productivity. Figure 17 shows fleet utilization rates during various off-peak periods across the top 5 transit agencies. In most cases, regardless of mode, less than one-half of the fleet is in revenue service (FTA, 2005).

Figure 17



Parry and Small (2005) estimate that variable operating costs per vehicle hour, excluding vehicle capital, are 25% greater during the peak than during the off-peak period. The increased cost is primarily due to the inefficiency of scheduling split labor shifts with down-time during the midday. Returning to the earlier study of the Los Angeles MTA, researchers concluded that total peak-period bus costs were 59% greater than total base-period bus costs. This difference is all the more remarkable given that the MTA has the third-lowest peak-to-base vehicle ratio of any major U.S. transit operator (Taylor et al., 2000).

Perhaps surprisingly, Parry and Small (2005) found that the marginal cost of supplying extra passenger miles is about the same, or higher, in peak compared to off-peak periods, even though vehicle occupancy rates are substantially higher. The reason is that peak service carries higher labor and vehicle capital costs, lower vehicle speeds, and longer dwell times at transit stops.

Scheduling Labor to Accommodate Peak Demand is More Expensive

As described previously, the 5 largest U.S. transit agencies spend an average of 82% of their operating budget on wages, salaries, and benefits (FTA, 2007). More than anything else, labor costs affect how service costs vary at different times of day. There are a couple of big reasons why labor costs during peak periods are particularly expensive. First, it is difficult to efficiently design work schedules when labor demand varies widely throughout the day. This task is made even more challenging when the use of part-time workers is limited by union contracts. Second, transit agencies typically assign full-time operators to work “split shifts” to accommodate the peak demand for labor. At the San Francisco Municipal Transportation Agency (MUNI), an operator might work 5 hours during the morning rush, take time off work, and then return for another 5 hour shift during the

afternoon rush. This work arrangement can be very expensive because union rules often require agencies to pay split shift premiums, overtime pay and/or guarantee pay. In this example, the operator is guaranteed 1.5 hours of overtime pay every shift because he/she is scheduled for more than 8 hours (plus a 30 minute lunch) in a day (Byrne, 1998).

To reduce labor costs, Nigel Wilson (2006) argues that transit agencies should hire a new class of part-time operators to work just the peak periods. He estimates that authorities could reduce operating costs by 1% to 10% by using part-time workers that receive reduced premium pay, lower wages, and fewer fringe benefits. Using more part-time employees, agencies can more efficiently manage employee schedules, reducing the number of workers during off-peak hours when demand is low, thereby reducing overall operating costs. The level of savings depends on the peak-to-base service ratio, restrictiveness of full-time operator work rules, and the extent of union concessions in negotiations to win the right to use part-timers.

Of course, transit agencies will face significant union opposition to any effort to expand the part-time workforce. At many agencies, union contracts limit part-time operators to a certain percentage of all positions. Unions for MUNI limit part-timers to no more than 5 hours per day. Thus, it may take a major event, like a budget crisis, to win union support for more part-time employees. Even then, part-time workers may only be hired at the rate of attrition of the regular, full-time workforce.

Wilson (2006) outlines several recommendations to expand transit agency use of part-time employees:

- Restructure limits on part-timers in terms of hours rather than headcount
- Create rules and procedures to attract those who want long-term part-time employment
- Offer stability in schedules across run cuts
- Offer flexible working hours and tailored duties
- Transition from two-piece to one-piece duties
- Develop some weekend part-time work
- Provide training during evening hours and on weekends
- Create dual hiring process for part-time versus full-time ranks

Part-Time Transit Employees May Cost More in Long Run

Despite studies that indicate the savings potential, an expanded part-time workforce may cost more in the long run. As noted previously, part-time workers often receive lower pay, fewer benefits, and less desirable routes and shifts than their full-time peers. Irregular schedules make it difficult for part-time workers to find another part-time position. Other industries can steal workers with comparable pay and better working conditions. As a result, it's difficult to attract talented, reliable part-time workers. Transit managers report that part-time bus

operators can contribute to higher absenteeism (TCRP, 1999). Overall, bus operators experience as much as 3 times the average rate of absenteeism as other blue-collar workers (Evans, 1994). Absenteeism drives up costs because union-represented full-time operators typically fill the void at time-and-a-half or better wages. Plus, replacement bus drivers are often less familiar with routes and traffic patterns which can lead to service delays and higher accident costs. Customers, frustrated at service delays, may choose to take alternative modes or voice their displeasure to bus operators, adding to driver stress. A 1980 study estimated that the national cost of bus operator absence translated to $3,750 (1995 dollars) per operator per year (TCRP, 1999). In 1997, a performance audit of MUNI concluded that because of operator absenteeism, 4% to 8% of the 1,201 daily runs never occurred and another 43% ran late. Muni's mechanics and maintenance workers had an even higher rate of unscheduled absenteeism than the drivers. As a result, Muni's fleet broke down twice as often as similar equipment operated by Boston, Seattle, and New York (Byrne, 1998). Part-time operators are also more likely to leave the transit agency than full-time employees. This increases costs for recruiting, hiring, and training new employees. TCRP (1999) reported that turnover was as high as 50% for part-time bus operators at one mid-sized agency.

More Agencies Seek to Implement "Programmed Fare Increases"

Of critical importance to cash-strapped transit agencies is how the elasticity values relate to revenue considerations. The relatively low peak period elasticity values suggest that transit agencies could raise peak period fares with minimal ridership loss. Further, the revenue lost from fewer riders would be more than off-set by the increased revenue per passenger from those who continue to ride the system.

In recent years, transit agencies have sought to take some of the politics out of fare policy by pushing for legislation that allows for automatic fare increases based on certain economic indicators. For example, the San Francisco Bay Area Rapid Transit District (BART) adopted a fare policy that enables automatic biennial fare increases based on the Consumer Price Index[6] less a 0.5% productivity factor "to represent BART's contribution to the cause of financial stability to parallel customers' contributions to the same cause in the form of higher fares" (Spock, 2007). BART first implemented the fare structure in January 2006, increasing fares by 3.7%. As a result, the average one-way BART fare rose from $2.51 to $2.70 (Cabanatuan, 2005). BART uses a distance-based pricing strategy with no time-based component. In January 2008, fares rose by 5.4% per the fare policy formula. BART estimates that FY09 passenger revenue will cover 57.9% of operating expenses (BART, 2008).

BART staff reported that several factors minimized public resistance to the new fare policy (Spock, 2007):

[6] BART uses a weighted average of two CPI indexes: (1) National CPI-U Annual Average; (2) Bay Area CPI-W Annual Average.

- Relatively small size of planned regular increases versus larger increases when the agency has substantial revenue shortfalls
- Using a widely known and understood measure (inflation), and very clearly expressing how the measure will be used to calculate the fare increase
- The Board's clear course of action which balanced the agency's financial needs with what is palatable to the customer
- High levels of customer satisfaction prior to the change taking place

While relatively rare, transit agencies of varying sizes use these so-called "programmed fare increases" and link them to different types of funding formulas. In fact, BART's neighbor, MUNI, has sought approval for an automatic biennial fare increase based on the U.S. Consumer Price Index and increases in the agency's own operating costs.[7]

More generally, Spock (2007) cites the following benefits of using a programmed fare increase:

- Minimize agency resources spent on political challenges to fare increases
- Maintain purchasing power of revenues collected, making it easier to balance the budget
- Eliminate need for larger "catch up" increases that are difficult for consumers to absorb, resulting in lost ridership
- More effectively manage capital programs and maintain service levels because revenue growth is more predictable
- Gain greater customer acceptance of fare increases that are predictable and well understood
- Stay in compliance with mandated farebox recovery ratios

Agencies Can Balance Fares and Service Levels for Greatest Public Benefit
For a given level of subsidy, transit operators can either provide a high level of service at a high price or a lower level of service at a lower price. It is reasonable to suggest that the objective of the transit agency is to maximize public benefits for a given level of subsidy. Economists explain that fares and service levels are "balanced" when the benefits to the riders are maximized given the amount of subsidy available. If they are unbalanced, riders can be made better off by reducing service levels and lowering fares, or, increasing service levels and raising fares, while keeping the overall level of subsidy constant. Using this idea, Savage (1999) studied one of the largest transit systems to understand how well fares and service levels were balanced. His research investigated the costs and benefits of reducing transit fares or increasing service levels. More specifically, the model calculated the benefits per dollar of subsidy used to finance a 0.10% change in fares and service levels. The model considered benefits to riders in the form of monetary savings (if fares are reduced) and waiting time savings (if frequencies are increased), plus benefits of reduced congestion to road users in peak periods

[7] Phone interview with Sonali Bose, Chief Financial Officer, San Francisco Municipal Transportation Agency, on 08/07/08.

if people are attracted out of their automobiles onto transit. Figure 18 displays the results by mode and time period. At the time of the study, this transit agency used a flat-fare structure.

If fares and service levels were balanced, not only between themselves but also across the different time periods, then the benefits per dollar of subsidy should be identical. Instead, the benefits of subsidizing fares are greater than the benefits of subsidizing increased service levels for both modes and in all time periods. The implication is that social benefits can be increased without the need for additional subsidies simply by reducing service levels and using the money saved to reduce fares. While Savage's study is part of a broader discussion that is well beyond the scope of the author's research, his results by time period are instructive. In particular, the greatest public benefit is realized by lowering bus fares during off-peak periods.

Figure 18

Benefit per Dollar of Subsidy				
	Weekday		Weekend	
	Peak	Off-Peak	Saturday	Sunday
Bus				
-Fare Decrease	$1.42	$1.90	$1.90	$1.92
-Service Increase	$0.24	$1.23	$1.38	$1.27
Rail				
-Fare Decrease	$1.27	$1.19	$1.19	$1.19
-Service Increase	$0.37	$1.06	$0.85	$0.59

CASE STUDY
PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH, PENNSYLVANIA

2007 Key Statistics (Federal Transit Administration)						
Service Area	Annual Unlinked Trips	Annual Passenger Miles	# Buses / # Train Cars	Peak-Base Ratio	FTE employees	Fares as % of Operating Funds Expended
775 mi^2	68,525,198	323,201,519	909/83	Bus (2.33) / LRT (4.07)	2,900	22%

Port Authority of Allegheny County (PAT) provides public transportation services within a 775 square-mile area, including the City of Pittsburgh and all of Allegheny County. The agency began operations in March 1964 when state legislation in 1959 enabled the consolidation of 33 private transit carriers. By combining fare structures and centralizing operations, Port Authority established the first unified transit system in Allegheny County. Today, PAT manages 183 bus routes, 5 light rail lines and 2 inclines. Additionally, PAT sponsors ACCESS, the nation's largest paratransit program of its kind for senior citizens and disabled residents. With annual ridership of more than 70 million trips, Port Authority ranks as one of the 25 largest transit agencies in the country.

Peak Pricing Impacts Few Riders

Port Authority uses a limited-scope time-based fare structure. First, the peak period, defined as 6:00AM-9:00AM and 4:00PM-6:30PM, is the shortest of any agency in this report. Second, peak fares are restricted to the rail network. Bus riders are not impacted. Third, peak pricing is directional, limited to in-bound traffic (towards downtown) in the morning and out-bound traffic (away from downtown) in the late afternoon. Finally, peak pricing applies only to cash customers. Riders using passes and other fare media do not pay peak fares. As a result, peak pricing affects a relatively small percentage of customers. For example, a customer would pay a peak fare during the morning commute only if using cash for an in-bound trip on the light rail system. Because PAT does not track hourly ridership, it's challenging to calculate what percentage of system riders pay the peak fare. Based on the following points, a conservative estimate is that 1.5% to 2% of all riders pay peak fares:

- Light rail represents 11% of total unlinked trips (FTA, 2007)
- 90% of rail riders travel in-bound in the AM and out-bound in the PM[8]
- 15-20% of rail riders use cash versus pre-paid media[9]

[8] Telephone conversation with David Wohlwill, Manager of Extended Range Planning, Port Authority, 03/25/08
[9] Telephone conversation with David Wohlwill, Manager of Extended Range Planning, Port Authority, 03/25/08

In conversations with agency officials, they were quick to point out that their peak pricing strategy was not based on goals of cost efficiency, service effectiveness, or social equity. Instead, it was a management initiative to minimize employee theft by reducing the opportunities for employees to handle cash[10]. Because PAT's rail operation is a barrier-free system, cash-paying customers pay the station agent. If the agent is not available, the conductor handles the payment. By charging a higher fare for cash customers, PAT management sought to encourage customers to migrate from cash to pre-paid media.

Peak Surcharges Vary by Distance Traveled

Port Authority uses a distance-based pricing strategy. The agency carves the service area into 5 pricing zones based on the distance traveled from downtown Pittsburgh. Customers ride for free within the five rail stations that make up the "fare-free" zone. Riders traveling within the "downtowner zone" pay about 25% less than they would for a one-zone ticket. Peak surcharges vary according to the number of zones included in the trip. For trips within the "downtowner zone", the peak surcharge is $0.25 or 14.3% of the total ticket price. For a peak trip that stays within a single zone, the surcharge is $0.50 or 20% of the total ticket price. Finally, a two-zone peak trip includes a $0.50 surcharge, which is 16.1% of the total ticket price. Because the peak surcharge is the same for one-zone and two-zone trips, riders taking longer trips tend to be less affected by the peak price component. For these riders, the peak surcharge is a smaller percentage of the total fare. Further, the peak surcharge per mile tends to be less than for those taking one-zone trips.

PAT Riders Not Representative of General Population

Port Authority's customer base is not entirely representative of the general population within its service area. While 35.6% of PAT riders come from households with no personal vehicles, only 29.4% of city residents and 16.2% of county residents face the same challenge. Further, 25.5% of all system riders have household incomes of $45,000 (2007 dollars) or greater. By comparison, 37.3% of city residents and 37.8% of county residents have household incomes of $60,200 (2007 dollars) or greater (Southwestern Pennsylvania Commission, 2007; U.S. Census, 2000). This data suggests that PAT customers may be disproportionately burdened by public policies that reduce service levels or increase the cost to use transit. A well-designed peak pricing strategy, impacting a much greater percentage of system riders, may lessen the negative impact on the poorest riders.

Rider Profile Varies According to Mode and Time Period

In 2007, the Southwestern Pennsylvania Commission (SPC) conducted an on-board survey of PAT riders. Figure 19 shows rider response by mode and time period (SPC, 2007).

[10] Telephone conversation, Carol Uminski and Chuck Imbrogno, Southwestern Pennsylvania Commission, 02/01/08.

Figure 19

	Peak		Off-Peak	
	Rail	Bus	Rail	Bus
HH with 2+ vehicles	61.2%	32.8%	46.7%	24.1%
HH Income of $45K+	61.9%	30.9%	39.1%	16.1%
Minority	9.4%	38.1%	14.3%	44.8%

Survey results are consistent with the earlier literature review. As one might expect, peak riders are more likely to be white, to earn more money, and to have more transportation alternatives than off-peak riders. This same pattern is evident when comparing rail riders to bus riders within peak or off-peak periods. During peak hours, the percentage of rail customers with household incomes above $45,000 is more than twice that of bus customers. Further, minorities make up less than 10% of peak rail riders, yet comprise nearly 40% of peak bus riders. It is not clear why there is such a stark contrast between rail and bus customers. One possibility is the rather skewed design of the light rail system, which primarily serves the southern sections of the city and county. Perhaps these southern neighborhoods are significantly more affluent and white than the county as a whole.

Port Authority's Peak Riders Show Some Unusual Characteristics

The SPC survey did yield one surprising result. During the peak period, 52% of rail riders are taking a non-work trip. Unfortunately, the survey did not specify what percentage of non-work trips were school-related versus a more discretionary trip linked to shopping, entertainment, or other social outings. This makes it more difficult to predict how many consumers might shift to an alternative time if they were impacted by peak pricing for the first time. As described below, rail riders taking a non-work trip during the peak period have fewer transportation alternatives than fellow riders on work-related trips:

- 70.6% of peak rail riders on work trips own 2+ vehicles
- 52.4% of peak rail riders on non-work trips own 2+ vehicles

Surprisingly, SPC officials estimate that the price elasticity of demand for peak riders is 1.46%. This statistic is highly unusual, suggesting that peak riders are relatively price sensitive. If this is correct, a fare increase will result in the loss of so many riders that total fare revenue will drop. Perhaps the relatively large percentage of peak riders taking non-work trips is a contributing factor to this elasticity value.

Lack of Data Makes Peak Pricing Analysis Difficult

Port Authority was unable to provide data that clearly demonstrates how peak pricing impacts ridership and revenue. PAT does not understand how riders respond to peak pricing because they do not track hourly ridership. In speaking with local officials, some of the challenge is due to antiquated systems, which produce little information that can be analyzed and distributed. When train or bus

operators fail to take manual steps to reset their fareboxes, they report back ridership data that aggregates multiple runs, making it more difficult for planners to efficiently schedule service[11].

Recent management decisions provide some insight into the relationship between pricing, service, and ridership. To close a FY08 budget deficit of $80 million, PAT management took the following action:

- Reduced service levels by 15% (effective 6/17/08)
- Increased "base fare" (off-peak, one-zone) by 14% (effective 1/01/08)
    - Equivalent to 2.8% annualized increase since last (9/02) increase
- Eliminated 370 budgeted positions; instituted 270 layoffs

Figure 20 provides detail on the new fare structure, effective 1/01/08.

Figure 20

	OLD		NEW		
	Peak	**Off-Peak**	**Peak**	**Off-Peak**	**% Peak Fare Increase**
Free Zone	Free	Free	Free	Free	N/A
Downtowner	$1.50	$1.25	$1.75	$1.50	17%
One Zone	$2.25	$1.75	$2.50	$2.00	11%
Two Zone	$2.75	$2.25	$3.10	$2.60	13%
Three Zone	N/A	$2.75	N/A	$3.25	N/A

Since the new fare structure took effect, rider response has been mixed. In the first month (January 2008), the public reacted to the higher fares with a 7.1% drop in ridership compared to the same period a year ago. However, by February, ridership rose by 4.3% versus last year. Despite higher fares and lower service, PAT achieved ridership gains because of the sharp rise in fuel prices. In effect, transit became more price competitive with private auto, encouraging existing riders to absorb the price increase and potentially attracting new riders. This result conflicts with the agency's price elasticity data, showing how difficult it can be to control for all the factors that affect rider response. Along with the 4.3% ridership increase, service productivity rose 15.2% versus last year. Rail vehicles that averaged 57 riders per hour a year ago now carried 68 riders. Buses gained four riders, to an average 31.7 riders per hour (Grata, 2008). Because PAT buses and train cars were not near capacity, they could easily absorb the increased passenger load without the need for incremental rolling stock. Some agencies, faced with maximum passenger loads, have successfully retrofitted their fleet to accommodate more passengers, saving costs by reducing the need to increase service levels.

[11] Telephone interview with Carol Uminski and Chuck Imbrogno from Southwestern Pennsylvania Commission on 2/01/08.

Overall, customer survey results were fairly consistent with the findings outlined in the literature review of this report. It is not surprising to learn that PAT officials have not studied the impact of a time-based fare structure because this pricing scheme was meant to reduce cash payments, rather than advance goals related to cost efficiency, service effectiveness, or social equity. If PAT chooses to pursue the latter, they may have an easier time broadening the scope of peak pricing because their customer base is already familiar with the concept. A steady rise in fuel prices should also dampen public opposition.

CASE STUDY
SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY
PHILADELPHIA, PENNSYLVANIA

2007 Key Statistics (Federal Transit Administration)						
Service Area	Annual Unlinked Trips	Annual Passenger Miles	# Buses / # Train Cars	Peak-Base Ratio	FTE employees	Fares as % of Operating Funds Expended
831 mi^2	321,839,783	1,430,190,884	1,363 / 885	Commuter Rail (3.0)	9,000	36%

Established in 1964, the Southeastern Pennsylvania Transportation Authority (SEPTA) is the nation's fifth largest public transportation system, offering a vast network of fixed route services including bus, subway/elevated, trackless trolley, light rail, and commuter rail. The agency serves Bucks, Chester, Delaware, Montgomery, and Philadelphia County, along with selected rail service to New Jersey and Delaware.

Peak Pricing Impacts Few Riders

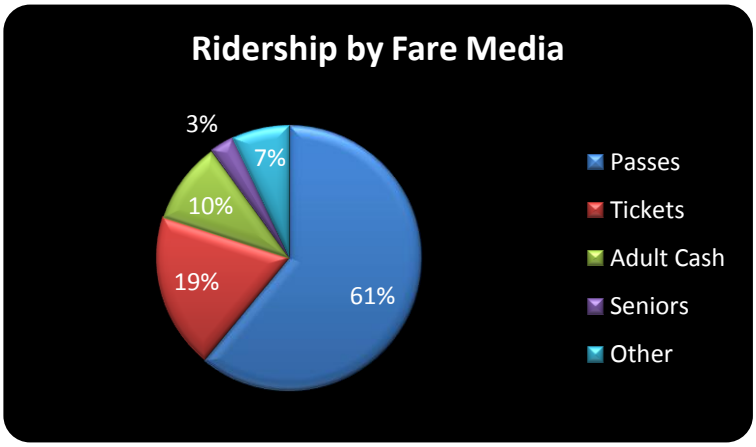
Similar to Port Authority of Allegheny County, SEPTA uses a limited-scope time-based fare structure. First, peak pricing is limited to SEPTA's regional rail service, which represents about 14% of system-wide unlinked trips. Regional Rail connects the outermost suburbs to Philadelphia's central business district, better known as Center City. Center City's three "hub stations" serve as the mid-point for each of the 8 major regional rail routes. Second, peak pricing is directional. Peak trains are defined as those arriving at the hub stations between 6:00AM-9:30AM or departing from the hub stations between 4:00PM-6:30PM. Reverse commuters are not impacted by peak fares. Trips during all other times, including weekends and major holidays, are considered off-peak. Third, peak pricing applies only to those travelers who alight at one of the hub stations. Passengers who alight before or after the hub stations do not pay peak fares. Fourth, peak pricing is limited to payments with cash or tickets, which represents about 29% of regional rail trips. For these reasons, relatively few Regional Rail customers pay the peak fare. Based on an April 24, 2007 ridership census, 31% of Regional Rail customers taking peak trips pay the peak fare (SEPTA, 2007b). As outlined in Figure 21, this translates to 19% of total daily boardings:

Figure 21

# of Peak Period Boardings	9,681
% Using Peak-Based Fare Media	31%
# Riders Paying Peak Fare	3,001
# of Daily Boardings	15,475
% of Daily Riders Paying Peak Fare	**19%**

Figure 22 provides fiscal year 2007 ridership by type of fare media.

Figure 22



Regional Rail Fares Depend on Time, Distance, and Ticket Purchase Site
Aside from peak pricing, Regional Rail fares depend on two other factors:

- **Distance:** 6 zones in network; crossing more zones increases ticket price
- **Ticket transaction site:** tickets purchased from conductor on-board cost more than buying from ticket agent at station

In 1981, SEPTA rezoned its service area into 6 zones to improve fare equity.[12] Zone 1 lies closest to Center City, with each successive zone located farther away from the City. Interestingly, SEPTA does not use peak pricing in Zone 1. Transit officials explained that very few riders would pay a peak fare at a Zone 1 station because they have alternatives (bus, trolley) that are cheaper and offer more frequent service. Those who do board at a Zone 1 station will typically use a pass, which is not impacted by peak pricing. Conversely, anyone using cash or tickets when boarding a Zone 6 station will pay a peak fare at all times. All Zone 6 stations are located in the State of New Jersey. Passengers boarding at Zone 6 stations pay the higher fare because New Jersey, unlike Pennsylvania and Delaware, does not subsidize SEPTA train service. Figure 23 displays the current fare structure for single-ride tickets by zone, time period, and ticket transaction site. Customers save 2-6% off the single-ticket price when purchasing round-trip tickets in advance.

[12] Telephone conversation, Dan Casey, Director of Revenue, Budgets, Pricing & Analysis, SEPTA, 10/29/08.

Figure 23

Zones	Peak Fare (Advanced Sale)	Peak Fare (On-board Sale)	Off-Peak (Advanced Sale)	Off-Peak (On-board Sale)
CCP/1	$3.50	$4.00	$3.50	$4.00
2	$4.25	$5.00	$3.50	$5.00
3	$5.00	$6.00	$4.25	$5.00
4	$5.50	$7.00	$4.75	$6.00
5	$6.00	$7.00	$4.75	$6.00
6	$8.00	$9.00	$8.00	$9.00

Different Fare Structure Applies to Trips Not Ending at Hub Stations
Regional Rail's fare structure includes other unique elements. Peak pricing is based on the premise that the vast majority of riders are traveling from the outlying suburbs to Center City during peak hours. Trips that fall outside this parameter are priced according to a different standard. Customers, who board a peak train headed towards Center City, but alight prior to reaching the three hub stations, pay an "intermediate branch fare", which is cheaper than the fare structure reflected in Figure 23. Separately, customers who board a peak train headed towards Center City, but travel through the three hub stations, alighting at a station beyond Center City, pay a "via center city fare", which is more expensive than the fare structure reflected in Figure 23. Peak versus off-peak pricing does not apply in these two instances because the trip does not end at one of the hub stations. Overall, 85% of riders alight at one of the three hub stations. Roughly 91% of riders alight within an expanded area that includes stations that are two stops away from the hub. An additional 1% of riders travel through the hub and another 8% alight at a local intermediate branch station[13].

The current peak pricing strategy is different from what was in place 25 years ago. Before 1984, SEPTA used peak pricing for the "via center city fare". However, management eliminated this because it applied to such a small number of riders (1% of peak riders) and often created confusion among customers. Also prior to 1984, peak pricing applied regardless of the trip's direction or destination. What mattered was whether you were on the train during the designated peak hours. Historically, the peak pricing strategy was not implemented to improve cost efficiency or social equity, but rather, to manage demand on strained capacity. In this way, it is similar to congestion pricing for urban freeways. Fifty years ago, when SEPTA travel patterns were more evenly spread throughout the day, peak pricing on Regional Rail was used to "keep the shoppers off the system because of capacity issues".[14] Over time, as transit patterns became more peaked and directional, the fare structure adjusted, in effect, offering "off-peak" discounts to reverse commuters, and those taking shorter trips ("intermediate branch fare") or traveling on the weekends.

[13] Telephone conversation, Dan Casey, Director of Revenue, Budgets, Pricing & Analysis, SEPTA, 10/29/08.
[14] Telephone conversation, Dan Casey, Director of Revenue, Budgets, Pricing & Analysis, SEPTA, 10/29/08.

Recent Initiatives Will Further Reduce Number of Riders Paying Peak Fares
In recent years, SEPTA has made several unpopular decisions that should result in fewer customers using cash or tickets on the regional rail service.

- **August 2006 – January 2007:** Removed electronic fare machines used to purchase advanced tickets at rail stations, forcing non-pass customers to wait in line for ticket agent (at station) or purchase tickets from conductor (on-board)
- **July 2007:** Levied ticket surcharge for fares purchased from on-board conductor, even though 75 of 153 rail stations offered no advance ticket sales from agent

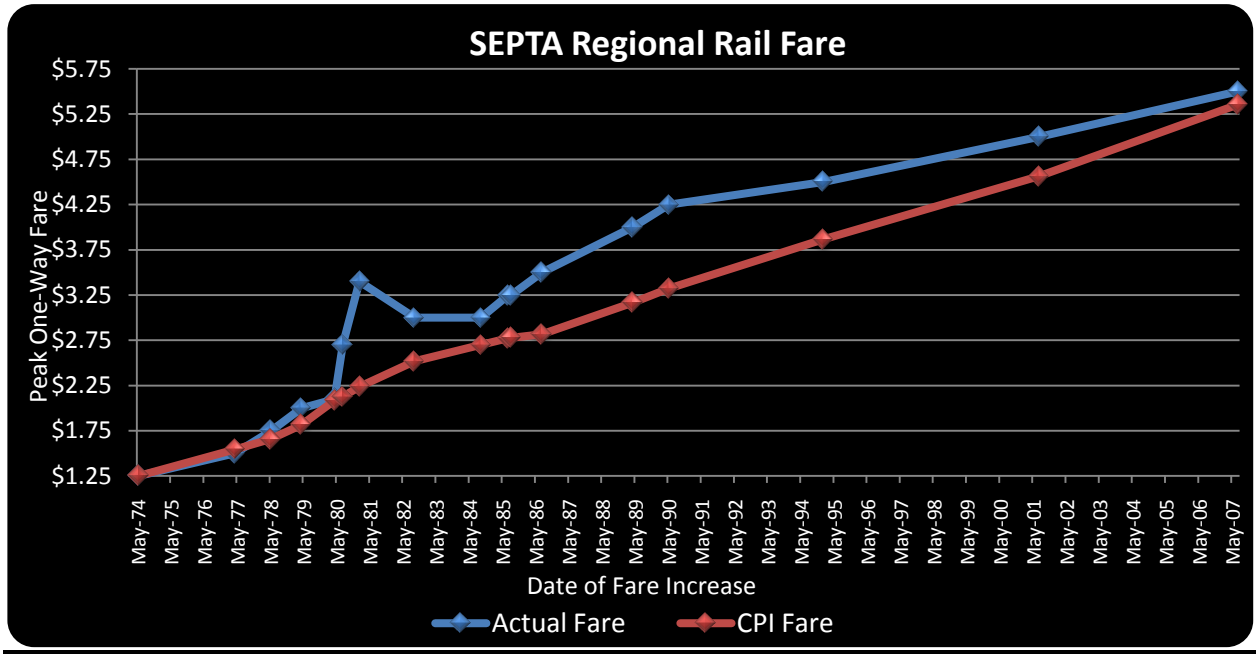
SEPTA management explained that the on-board surcharge was to reduce labor costs for handling cash on-board. However, public outcry was so great that the agency instituted a new fare credit program. Riders who paid an on-board surcharge for their initial trip could deduct the surcharge from their return trip ticket provided it was the same day. However, given the extra steps needed to receive the credit, it is likely that only the most price sensitive consumers will pursue the credit.

Despite Fare Increases Ridership Reaches 30-Year High
After a 2001 fare increase, SEPTA's Regional Rail division held the line on future increases until July 2007. At that time, the agency increased all pass prices (weekly, monthly) by an average of 11%, affecting 61% of riders. In August, peak-hour customers using the TransPass to travel to Zone 1 or hub stations had to switch to the TrailPass, which had increased in price by 20% in July (King, 2007). Despite two fare increases this decade, ridership has grown dramatically. From 2000 to 2007, trips on Regional Rail grew by 17% (Nussbaum, 2007). At the time of the 2007 fare increase, transit officials predicted a 2.6% ridership decline. Yet, 6 months post-fare hike, ridership was up by 12%, or 13,000 daily trips, versus the prior year. Ridership had reached its highest levels since the 1970s. SEPTA management cited higher fuel prices and increased highway congestion as two of the biggest reasons for the ridership gains (Geringer, 2008). This trend supports earlier research discussed in this report's literature review. The cost to commute by car rose dramatically, making SEPTA's regional rail service much more price competitive, especially for those taking long-distance trips to the Center City during peak hours. What was unclear to the author was why higher fuel prices didn't lead to less highway congestion due to fewer cars on the roadways. Perhaps suburban growth or deteriorated highway infrastructure contributed to increased congestion even though some residents took fewer auto trips.

Fare Increases Have Trended Ahead of Consumer Price Increases
Since 1974, SEPTA has adjusted fare levels 16 times on its regional rail service. Figure 24 displays the historical trend, comparing the actual fare (nominal dollars) to a CPI-adjusted fare (real dollars). This graphic charts the price of a one-way peak fare from the Bristol station (Zone 4) to Center City on the R7 line, a distance

of about 24.5 miles. Using the May 1974 fare as a starting point, the "CPI Fare" follows a path according to the increase in the Consumer Price Index (CPI), produced by the U.S. Bureau of Labor Statistics. For example, in August 1985, riders were charged $3.25 for their trip. From May 1974 to August 1985, CPI increased by 122%. If SEPTA had tied fare increases to CPI, this same trip would have increased from $1.25 (1974) to $2.78 (1985). Based on the graph, the "Actual Fare" closely paralleled the "CPI Fare" through the late 1970s. Over the next decade, the "Actual Fare" trended above the adjusted fare. By 1990, riders were paying 27.9% more than if the fare had been tied to CPI. Since that time, the gap has narrowed, due to significantly fewer fare adjustments over the last 15 years. By July 2007 (the last fare increase), the "Actual Fare" was only 2.6% greater than the "CPI Fare". This narrowing may be a significant factor behind the big ridership gains over the last 10 years. As discussed in the literature review, an increasing number of transit agencies have adopted programmed fare increases. These agencies automatically increase fares every one to two years based on the increase in certain economic indicators.

Figure 24



Similar to Port Authority, SEPTA fares changed dramatically in the early 1980s. As the federal government scaled back operating subsidies, SEPTA raised fares to close the budget gap. In July 1980, just four months after the last increase, fares rose from $2.10 to $2.70. Six months later, fares rose again to $3.40. Faced with significant budget challenges and plunging ridership, SEPTA took radical action to reduce expenses. They won several concessions from labor unions, enabling them to privatize certain positions (police, sanitation, ticket

agents) for one-third of the original cost[15]. As a result, SEPTA reduced fares in September 1982, lowering the fare to $3.00. The fare would not reach previous levels until July 1986, when fares hit $3.50. Unfortunately, SEPTA could not provide any studies that showed how ridership responded to the frequency and level of fare changes. Even today, SEPTA does not use price elasticity models to predict how fare changes will impact ridership across various customer segments and during different time periods.

Infrequent Off-Peak Service Limits Opportunity to Delay Peak Trip

Although lacking price elasticity data, SEPTA might assume that their Regional Rail customers are more price inelastic than those riding other systems that use a time-based fare structure. This is primarily due to relatively infrequent service immediately before or after the designated peak period. For example, the very first morning train on the R7 line, providing service from Chestnut Hill East (outermost station) to Center City, is considered a peak train. During the peak, the train departs Chestnut Hill East every 15 to 30 minutes. However, the first off-peak train departs for Center City one hour after the last peak train. Thus, it's not surprising that the number of riders boarding at the Chestnut Hill East station between the last peak train (8:19AM departure) and the first off-peak train (9:19AM departure) drops by 67%. This may indicate that SEPTA has more opportunity to increase peak fares without losing riders to off-peak times.

By contrast, service on the opposite end of the R7 line, from Trenton, New Jersey to Center City, provides slightly more frequent service. The last morning peak train departs 33 minutes before the first off-peak train. Thus, the number of boardings at Trenton between these two runs drops by only 7%. This may indicate that riders are willing to delay their trip in order to realize savings on the fare. It should be noted that while the first off-peak train departs 33 minutes after the last peak train, it arrives in Center City only 28 minutes after the last peak train, saving 5 minutes in transit.

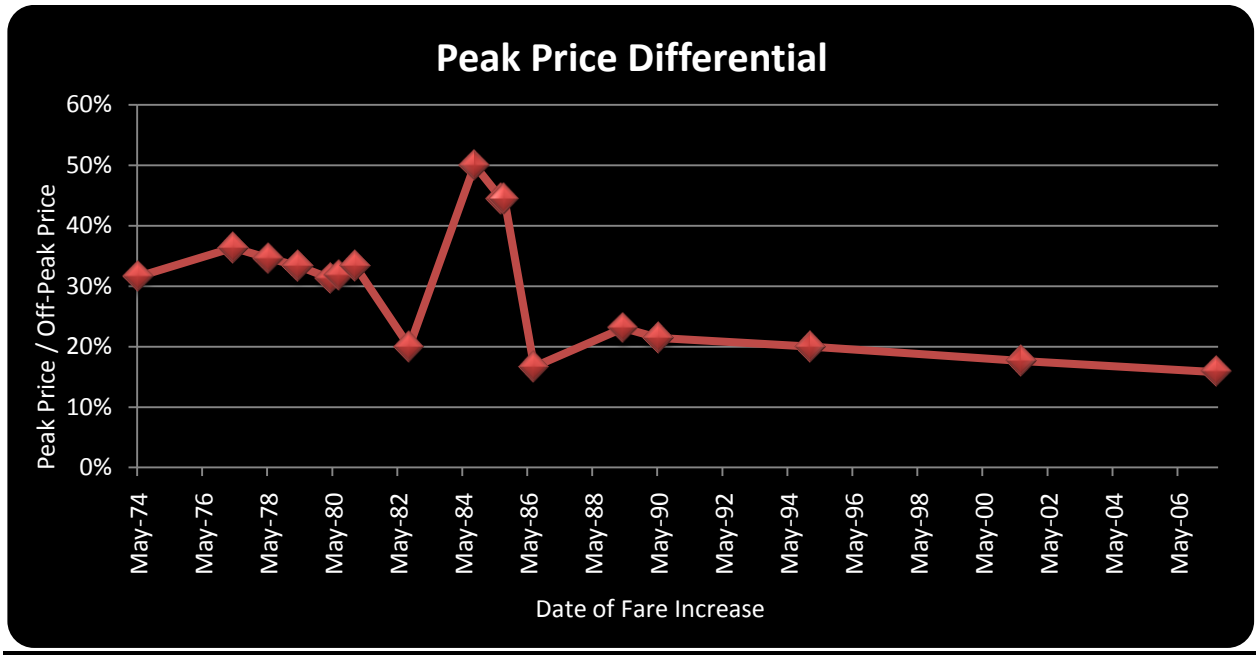
Gap Between Peak Fare and Off-Peak Fare Has Shrunk Over Time

Using the earlier example, Figure 25 measures the price difference between the peak fare and the off-peak fare for the ride from the Bristol station to Center City. During the mid to late 1970s, the peak fare was between 30% and 40% greater than the off-peak fare. In the early 1980s, frequent fare changes affected this price differential, reaching as high as 50% (1984) and falling to as low as 20% (1982). Since 1990, the gap between the two pricepoints has steadily shrunk. Currently, the peak fare is 16% greater than the off-peak fare. It is unclear how SEPTA policy goals, either directly or indirectly, impacted the price differential. As described earlier, a lack of data precludes a detailed analysis to understand how peak travel was impacted by the shrinking gap between peak and off-peak prices in recent years. Principles of economic efficiency dictate that the price differential reflects the difference in service costs between the two time periods. However, as discussed in the literature review, few agencies use sufficiently sophisticated cost

[15] Telephone conversation, Dan Casey, Director of Revenue, Budgets, Pricing & Analysis, SEPTA, 10/29/08.

allocation models to understand this difference. Instead, agencies use other factors to determine the price differential, which may not be tied to service costs at all. For example, a transit authority might use peak pricing to address capacity constraints by pricing the peak fare at such a premium that it encourages peak riders, taking discretionary trips, to switch to off-peak times, immediately before or after the designated peak period. If capacity is not an issue, an agency might establish a price differential that isn't great enough to encourage a significant number of peak travelers to switch to the off-peak period. This could allow the agency to retain most of its peak riders and generate more total fare revenue. Of course, successful implementation of this pricing scheme will depend upon a number of factors, including capacity, price elasticities, service effectiveness, and the price competitiveness of alternatives to transit.

Figure 25



Regional Rail Riders Pay Greater Share of Costs, Similarly Satisfied

Regional Rail tends to attract riders who travel relatively long distances during peak hours. As a result, these customers usually pay a higher average fare than those traveling within the flat-fare structure of SEPTA's light rail, trolley, subway, or bus system. Regional Rail's 2007 total operating expense (including capital depreciation) per passenger of $7.29 is much greater than that of the City Transit division ($3.77), yet passenger revenues cover a greater percentage of these expenses. For example, Regional Rail's average fare is 2.5 times that of City Transit (intra-city buses/trains), yet their operating expense per passenger, including capital depreciation, is only 1.9 times greater than that of City Transit. Figure 26 displays FY07 data for SEPTA's three transit divisions.

Figure 26

Division	Avg. Fare per Linked Trip	Farebox Recovery Ratio[16]
Regional Rail	$3.17	43.4%
Suburban Transit	$1.41	23.1%
City Transit	$1.26	33.4%

In fiscal year 2007, Regional Rail represented 29.3% of total SEPTA revenue, but only 10.3% of unlinked trips and 14.3% of linked trips (SEPTA, 2007a).

Despite paying a significantly higher average fare, Regional Rail riders indicate on customer surveys that they feel they are receiving a value for their dollar that is similar to that expressed by those using SEPTA's other services. Figure 27 displays the 5-year average from customer surveys which asked SEPTA riders about the "value of service for the money paid". The satisfaction rating is based on a scale from 0-10, in which "0" is the worst possible rating and "10" is the best possible rating. Regional Rail customers showed the same satisfaction levels as City Transit riders, and only 2.5% less than that of Suburban Transit customers. This finding is consistent with earlier discussions indicating that riders often respond more to service than price. In this case, Regional Rail customers may be willing to pay higher fares because of added comfort, speed, and reliability.

Figure 27

Recent Fare and Service Changes Provide Opportunity for New Studies

Recent events provide new opportunities to evaluate the impact of price and service on ridership by time period. In August 2007, SEPTA tapped public funds from the Pennsylvania State Lottery to reduce peak fares for senior citizens. Previously, customers who were 65 years of age or older paid $1 for their

[16] Farebox Recovery Ratio = Passenger Revenue / Total Expenses (includes capital depreciation)

Regional Rail tickets, except for 7AM-8AM and 4:30PM-5:30PM, when they paid full fare. Starting in August 2007, seniors began to ride for $1 per trip regardless of the time of day (Geringer, 2007). Studies should explore how seniors have responded to this switch from peak pricing to a flat-fare structure.

Lately, SEPTA has introduced more service to accommodate additional riders. In September 2008, off-peak service on the R5 line increased from every 60 minutes to every 30 minutes. In addition, new early morning service from the outermost station will make runs before the peak period begins (Upholt, 2008). Studies should explore how expanding off-peak service impacts when people choose to ride the system.

Like Port Authority, SEPTA's peak pricing strategy is not related to cost efficiency, service effectiveness, or social equity. In SEPTA's case, peak pricing was first implemented to deal with capacity constraints during peak hours. However, several policies conflict with this goal. First, few peak riders actually pay peak fares. Second, infrequent off-peak service provides less opportunity for peak riders to delay their trip to the off-peak period. Third, a shrinking gap between the peak price and off-peak price means a smaller price advantage for riding in the off-peak. Big gains in peak ridership over the last couple of years place more pressure on SEPTA management to add costly peak service and increase rolling stock. Given these trends, a redesigned peak pricing strategy could become a more effective demand management tool.

CASE STUDY
METRO TRANSIT
MINNEAPOLIS – ST. PAUL, MINNESOTA

2007 Key Statistics (Federal Transit Administration)						
Service Area	Annual Unlinked Trips	Annual Passenger Miles	# Buses / # Train Cars	Peak-Base Ratio	FTE employees	Fares as % of Operating Funds Expended
584 mi^2	76,966,724	356,185,409	886 / 27	Bus (2.4) / LRT (1.1)	2,644	31%

Serving Minneapolis, St. Paul, and the suburbs within a seven-county region, Metro Transit manages one light rail line, 63 local bus routes, 46 express routes, and 9 contract routes. The agency is responsible for 95% of the region's 73 million bus trips each year.

Metro Transit is an operating division of the Metropolitan Council, the regional planning agency responsible for managing transportation, wastewater treatment, affordable housing, and parks and trails. Metro Transit relies heavily on state and federal dollars to finance operational and capital programs. Policy requires that passengers cover one-third of the operating budget. For fiscal year 2008, Metro Transit expected to collect 29% from passenger fares, 58% from state appropriations and motor vehicle sales, 8% from the federal government, and the remainder from local and self-generating sources (Metropolitan Council, 2007a). It appears that self-generating sources count towards the mandated one-third farebox recovery ratio.

Metro Transit Uses Time-Based and Service-Based Pricing

Metro Transit uses a time-based and service-based fare structure. Unlike Port Authority and SEPTA, Metro Transit has implemented an expansive peak pricing strategy. Peak fares apply to bus and rail, regardless of direction, for any trip taken Monday through Friday between 6:00AM-9:00AM or 3:00PM-6:30PM. Further, peak pricing impacts most fare media types. Express bus routes are priced higher than local-service bus routes. Light rail service is always considered local service. Figure 28 outlines the current cash fare structure, effective 10/01/08:

Figure 28

Service	Peak Fare	Off-Peak Fare
Local	$2.25	$1.75
Express	$3.00	$2.25

Upon request, customers receive a free transfer to bus or rail, permitting unlimited rides within 2.5 hours from the time of the original trip. However, any customer who transfers from a lower cost trip to a higher cost trip (e.g. off-peak to peak, local to express) must pay the price difference when they board the transfer trip. A significant number of customers take transfer trips. On a typical weekday, 33% of unlinked trips are transfer trips. It would be instructive to study how transfer rates differ by mode and time period. It is reasonable to assume that transfer rates might be higher in off-peak hours when more customers use local bus service to reach destinations away from the city center. The majority of transit networks are designed to provide the shortest route to the central business district.

Metro Transit Offers Many Fare Media Options

Metro Transit offers fare media tailored to many different customer segments:

- **SuperSavers 31-Day Pass:** Purchase price depends on fare level from Figure 28. Discounted rate based on 42 rides within a 31-day period. Price discount varies: at $1.75 fare level, price discount is 19.7%; $2.25 level (10.1%); $3.00 level (9.9%). After 42nd ride, all trips within same 31-day period are effectively free.
- **SuperSavers Stored Value Card:** Sold in denominations of $10, $20, and $40 (magnetic stripe) or any amount desired (smartcard). Each pass includes 10% bonus added to value on card. Regular fare deducted from card value as outlined in Figure 28.
- **Monthly Pass:** unlimited ride pass for train service only
- **Day Pass:** unlimited rides on bus or rail for 24 hours
- **6-Hour Pass:** unlimited rides on bus or rail for 6 hours

Additional fare media options are offered to eligible customers:

- **Senior citizens (65+), Youth (6-12 years old), and Medicare card holders** pay regular fare during peak hours. Ride for $0.50 during off-peak.
- **Disabled citizens:** ride for $0.50 at all times.
- **College students:** purchase discounted unlimited ride passes by semester.

Figure 29 shows the number of total bus riders by fare media for a typical weekday (Metro Transit, 2008)[17].

[17] Source: Metro Transit bus ridership (local, limited stop, and express service), excluding transfers on 04/22/08.

Figure 29

Total Bus Ridership		
Fare Media Type	**# Riders**	**% of Total**
Metropass	31,344	19%
Stored Value	30,130	18%
Cash	29,907	18%
College	20,873	13%
31-Day Pass	18,200	11%
Disabled	9,111	6%
Free Rides[18]	8,300	5%
Coupons/Tokens[19]	6,452	4%
Youth/Young Adult	5,698	3%
Seniors	3,878	2%
Downtown[20]	1,685	1%
TOTAL	**165,578**	**100%**

Perhaps surprisingly, more bus riders use Metropass than any other payment type. In the Metropass program, companies partner with Metro Transit to offer heavily discounted unlimited ride monthly passes to their employees. Employers pick from three options:

1. Bear the full cost, offering free transit services to employees. Companies benefit from payroll tax savings and state tax credits.
2. Subsidize a portion of the cost, reducing employees' transit expenses. Companies benefit from payroll tax savings and state tax credits on the subsidized amount.
3. Enroll in the program and ask participating employees to pay the full cost through pre-tax payroll deduction. Employees pay $76.00 for the unlimited ride monthly pass. Companies benefit from payroll tax savings.

Participating employees use their Metropass smartcard to board any train or bus at any time. Across the three options, employees pay an average monthly cost of about $45.00, a 47% savings from even the deeply discounted 31-Day Pass (at $2.25 level).

Different Customer Segments Take Transit at Different Times

High customer usage of Metropass is consistent with earlier statements that an increasing percentage of riders take work-related trips in peak hours to center city locations that are best served by transit. Figure 30 shows local-service bus ridership by fare media and time period[21] (Metro Transit, 2008). As expected, the vast majority (78%) of Metropass trips occur during peak hours. Conversely, cash customers take more off-peak trips, effectively cross-subsidizing the peak trip of wealthier customers who tend to use unlimited ride passes.

[18] Free Rides include: (1) transit employees, (2) operator override due to equipment failure
[19] Coupons/Tokens provided by: (1) social service agencies for low-income riders; (2) Metro Transit marketing department for new residents, loyalty-based programs, etc.
[20] Bus or train rides within a designated area of downtown Minneapolis and downtown St. Paul are $0.50 at all times
[21] Source: Metro Transit bus ridership (local service), excluding transfers on 04/22/08.

Figure 30

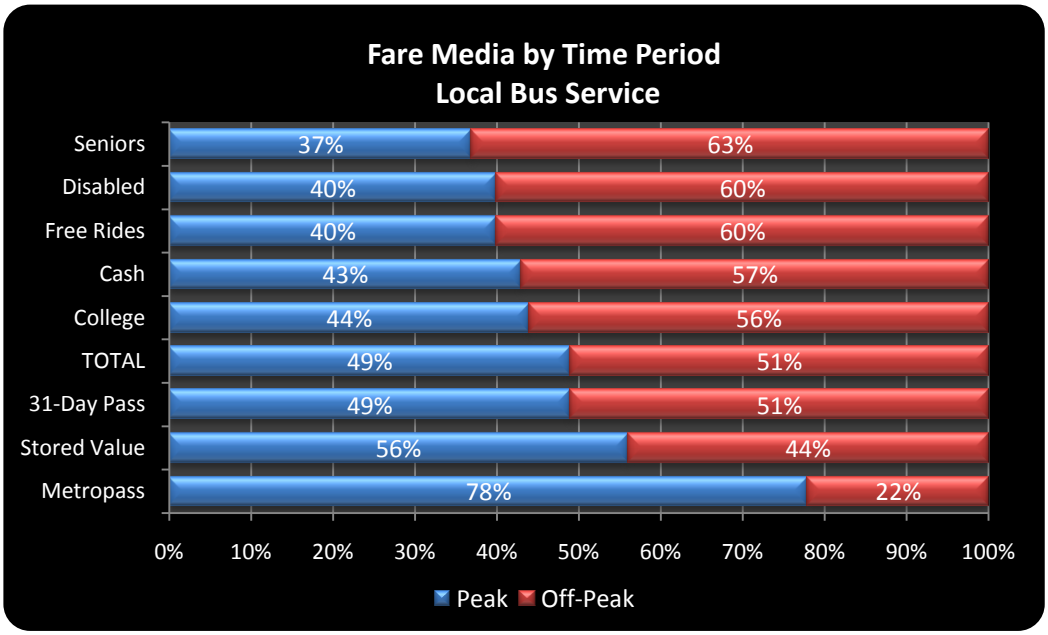


Figure 30 provides insight on other relevant issues. First, senior citizens enjoy a 67% price discount for off-peak versus peak trips. Given this, it's reasonable that 63% of senior trips occur during off-peak hours. While price may play a major role in purchase decisions by fixed-income seniors, a contributing factor is that most seniors are retired, thus, not following the typical peak period travel pattern of commuters. Separately, it's not clear why a greater percentage of Stored Value trips (56%) occur during peak hours than 31-Day Pass trips (49%). Riders using a Stored Value card pay the full fare price per trip while 31-Day Pass users presumably pay much cheaper fares. Perhaps, the Stored Value customer doesn't use transit enough to realize the benefit from the 31-Day Pass. Also, the relatively large upfront payment ($85.00 at the $2.25 fare level) may be too costly for some. Alternatively, the 31-Day Pass holder may use transit as their primary transportation mode, taking a greater share of off-peak trips for discretionary purposes.

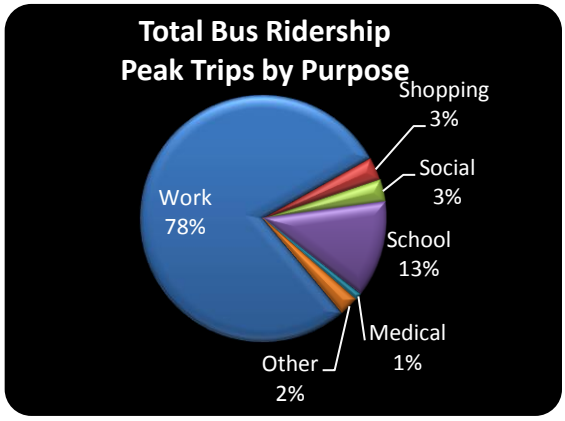
Peak Trips are Work-Related; Off-Peak Tied to Shopping & Social Activities

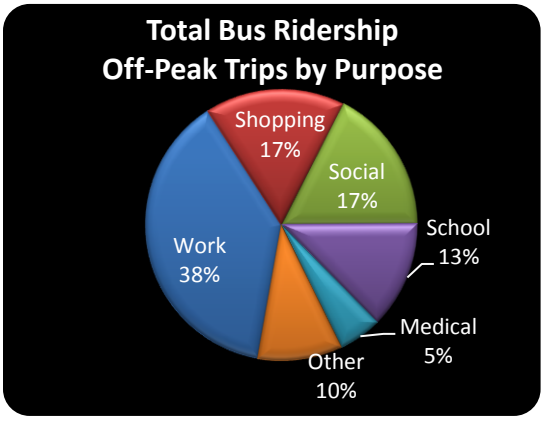
Since 1993, Metro Transit has conducted an annual customer survey to quantify rider opinions and perceptions of existing service and communications programs. This section provides several graphs based on 2006 survey results[22] (Metro Transit, 2006). Figure 31 displays total bus ridership by purpose for peak versus off-peak periods.[23] Survey results are consistent with earlier discussion in this report's literature review. As expected, peak trips are heavily work-related. School-related trips are often considered non-discretionary trips because students cannot choose when to start class. Thus, 91% of peak ridership on bus is non-

[22] Metro Transit, Bus Rider Survey, 2006, N = 6,592, Response Rate = 33%
[23] Source: Metro Transit Bus Rider Survey (local, limited stop, and express service).

discretionary. By contrast, only 51% of off-peak trips are non-discretionary. In fact, during the off-peak, trips related to shopping and social activities are nearly as numerous as work-related trips.

Figure 31





Higher Income Riders Tend to Take Peak Trips

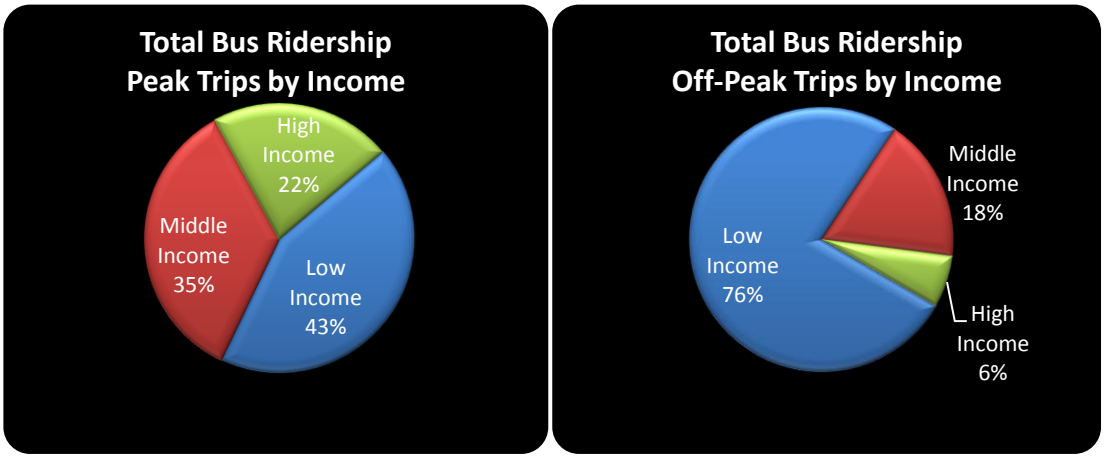
Figure 32 compares peak versus off-peak bus trips by income level[24] (Metro Transit, 2006). Based on U.S. census data, the median family income within Metro Transit's service area is approximately $61,600 in 2006 dollars[25]. Figure 32 groups income data into three broad categories:

- **Low Income:** 0-70% of median family income
- **Middle Income:** 71-130% of median family income
- **High Income:** 131% or more of median family income

The pie charts clearly show that peak trips include a much greater percentage of Middle Income and High Income riders than off-peak trips. During the peak period, 22% of bus riders earn at least 131% of the median family income. This statistic shrinks to 6% in the off-peak. Although not presented in Figure 32, 93% of High Income bus riders travel during the peak period.

[24] Source: Metro Transit bus survey (local, limited stop, and express service).
[25] Source: U.S. Census Bureau, 2005-2007. Metro Transit service area was represented by a weighted average of two census classifications: Metro Region (30%), Minneapolis City (70%).

Figure 32



Peak Riders Motivated Somewhat Differently than Off-Peak Riders

Survey results indicate that peak riders are motivated to use transit for somewhat different reasons than off-peak riders. Figure 33 shows results for Metro Transit's local-service bus riders[26] (Metro Transit, 2006). Peak riders are more likely to use transit because their employer subsidizes their ride. Further, saving money on parking and car expenses are bigger motivating factors for peak riders. By contrast, off-peak riders are more likely to use transit because they don't own a car or one is not available to them. These riders are also more likely to use transit because it saves them time. One might assume that transit is viewed as a time-saver over alternatives that don't involve a car, such as biking or walking. A roughly similar proportion of peak riders and off-peak riders cite convenience and the environment as the biggest reasons they take transit.

Figure 33

Biggest Reason for Using Transit		
Local Bus Service		
	Peak	**Off-Peak**
Do not own car	31.4%	41.7%
Convenience	19.1%	17.0%
Saves money on parking	14.9%	7.4%
Car not available	9.7%	12.6%
Saves money on car expenses	6.8%	5.4%
Avoid stress of driving	5.5%	3.5%
Environmental	5.2%	5.5%
Saves time	2.8%	3.6%
Other	2.2%	2.8%
Subsidized by employer	2.0%	0.2%
Metro Transit promotion	0.4%	0.2%
TOTAL	**100%**	**100%**

[26] Source: Metro Transit Bus Rider Survey, local bus service.

Peak Rail Riders Vary from Peak Bus Riders in Important Ways

Metro Transit's survey provides the opportunity to examine how rail riders differ from bus riders when comparing travel behavior by time period. Figure 34 shows this variation for several factors. On rail, 13.3% of peak riders have no available automobile compared to 29.9% of off-peak riders. On bus, 43.7% of peak riders have no available automobile compared to 66.7% of off-peak riders. Thus, the percentage spread between the two rail values is greater than the spread between the two bus values. One possible explanation is that the profile of the typical peak rail rider is different from that of the typical off-peak rail rider, and that rail passengers are less likely to take trips during both the peak and off-peak period. In other words, there tend to be a lot more customers who use rail exclusively during the peak, and these riders are fairly distinct from the smaller percentage of rail customers who take both peak and off-peak trips. Separately, bus riders are much less likely to have access to an available automobile, indicating that they probably earn less than rail passengers who travel during the same time period.

Significant variation occurs for trip purpose and transfer rates. On rail, 88.5% of peak riders are traveling for work compared to 41.2% of off-peak riders. Fewer bus trips are work-related. Additionally, the spread between peak and off-peak riders is less for bus than it is for rail. As for transfer rates, 42.2% of peak rail riders transfer compared to roughly the same percentage (46.0%) of off-peak riders. However, peak bus riders are much less likely to transfer than off-peak bus riders. This is consistent with earlier research that indicates that off-peak bus travel tends to be for discretionary trips away from the central business district, which often necessitates more transfer trips.

Further, the table shows variation by mode for "middle-income" riders or those from households earning between $40,000 and $80,000 (2006 dollars). On rail, the percentage of middle-income riders during the peak is slightly more than the same earners riding in the off-peak. On bus, nearly twice as many middle-income residents travel during the peak than in the off-peak. It's not clear why so many middle-class residents take light rail in the off-peak. Perhaps this group is more likely to take the system's only light rail line for special purpose trips during the off-peak because it is so well-connected to professional sports venues and the Mall of America.

Finally, it is valuable to compare survey results in Figure 34, which reflects local bus service, to survey results in Figures 31 and 32, which reflect total bus ridership, including local service, limited stops, and express service (Metro Transit, 2006). Bus riders using express service tend to be higher-income, suburban residents who primarily use transit for the work-related trip. Metro Transit's express service is designed for downtown-oriented trips during peak hours. Thus, it's not surprising that 78.0% of total bus trips during the peak are work-related compared to 66.1% of local-service bus trips during the same timeframe. Further, it's expected that express service carries a significantly greater percentage of high-income riders (those living in households earning more than $80,000 in 2006

dollars) than local service. In fact, 22.5% of total peak trips are taken by high-income earners as compared to 11.3% of local-service, peak trips alone.

Figure 34

Local Service[27]				
	Rail		Bus	
	Peak	Off-Peak	Peak	Off-Peak
% Work Trip	88.5%	41.2%	66.1%	36.0%
% School Trip	6.5%	6.1%	17.5%	12.6%
% Transferring	42.2%	46.0%	48.1%	60.4%
HH Income: $0-40K	30.3%	47.6%	59.5%	78.5%
HH Income: $40-80K	38.7%	32.5%	29.1%	15.6%
HH Income: $80K+	31.0%	19.8%	11.3%	5.9%
0 Autos Available	13.3%	29.9%	43.7%	66.7%
1 Auto Available	41.3%	37.4%	36.1%	23.1%
2 Autos Available	36.2%	25.7%	15.3%	6.6%
3 Autos Available	9.2%	7.0%	4.9%	3.6%

Peak Bus Riders Will Drive Alone; Off-Peak Most Likely to Cancel Trip
The following two bar graphs examine transportation alternatives available to passengers by mode and by time period. More specifically, these graphs represent survey responses to the question: "If transit had not been made available, how would you have made this trip?" Figure 35 shows results for local bus passengers. Peak bus riders were most likely to drive alone and least likely to carpool. Off-peak bus riders were most likely to cancel their trip and least likely to carpool. The off-peak response is consistent with the idea that significantly fewer off-peak bus passengers have access to a private automobile. Comparing the peak versus off-peak response, peak riders are much more likely to drive alone and carpool than off-peak riders. Conversely, off-peak riders are much more likely to cancel their trip or walk than peak riders.

Off-Peak Rail Riders More Likely to Take Taxi or Bike than Peak Riders
Figure 36 shows the same type of information for rail. Peak rail riders are most likely to drive alone and least likely to walk. Off-peak rail riders are most likely to drive alone and least likely to carpool. Peak passengers are much more likely to drive alone and carpool than off-peak passengers. Conversely, off-peak riders are more likely to take a taxi or bike than peak riders. Given that off-peak travel tends to cover shorter distances and to be for more discretionary purposes, it's not surprising that consumers would take a taxi or bike. These modes are more affordable and/or more practical over shorter distances.

As stated previously, peak riders are more likely to drive alone than off-peak riders. However, this difference is much more pronounced among bus passengers than rail passengers. This may be because of the greater variability in car

[27] Source: Metro Bus/Rail Rider Survey. Bus data in this table reflects local service and will vary from data presented in Figures 31 & 32, which reflect total bus ridership (local-service, limited stop, express)

ownership rates for bus passengers versus rail passengers. Rail passengers, whether peak or off-peak travelers, tend to have relatively high car ownership rates. Separately, off-peak riders are more likely to take a taxi than peak riders. Yet, this difference is significantly greater among rail riders than among bus riders. This might have something to do with rail customer's willingness to pay a premium for the convenience of taking a taxi. Further, rail passengers may be more likely to live along major street corridors that are well served by taxi cabs.

Figure 35

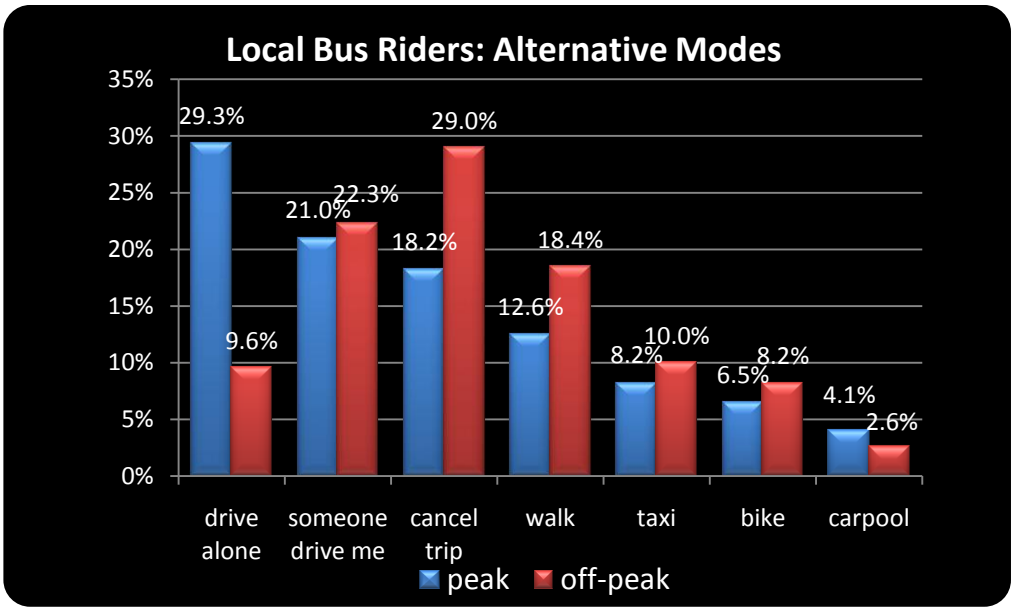
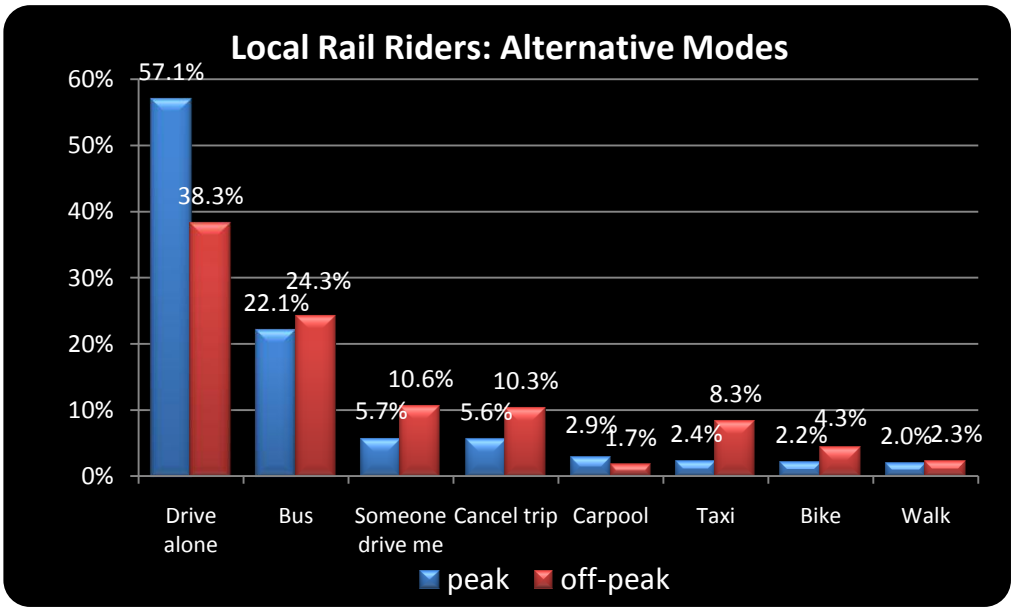
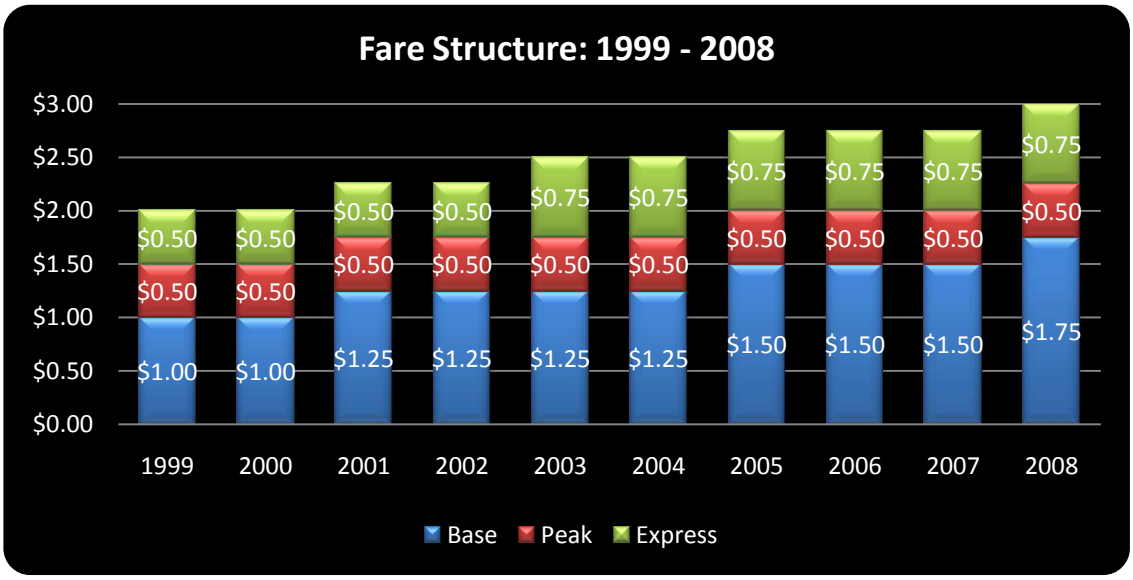


Figure 36



Metro Transit's Peak Price Component is Unchanged over Last 10 Years
Figure 37 shows Metro Transit's fare structure over the last 10 years (Metropolitan Council, 2007a). The total fare price can be based on three components: **base price, peak price, and express price**. For example, the current base price (equivalent to local off-peak bus service) is $1.75 per trip. If taken during peak hours, the peak price of $0.50 is added to the fare. If taken on an express bus, the express price of $0.75 is added to the fare. Thus, a peak express trip costs a total of $3.00.

Figure 37



Over the past ten years, the base and express components have increased but the peak component has remained constant. In effect, the peak fare component represents a shrinking percentage of the total cost of the fare. In 1999, the peak component ($0.50) represented 33% of the total cost of a peak local-service trip ($1.50). Today, the peak component ($0.50) represents 22% of the total cost of a peak local-service trip ($2.25). As discussed in the SEPTA case study, this trend suggests that Metro Transit's peak pricing strategy holds less influence over consumer's purchase decision with respect to travel time. In other words, consumers pay less attention to the peak versus off-peak price differential because the peak component is a smaller percentage of the total fare price. If Metro Transit seeks to use peak pricing, at least in part, to influence when riders use the system, they should consider increasing the peak component in future fare increases. At a minimum, transit officials should seek to keep the peak component at a constant percentage of the total fare price.

While the peak component may hold less influence today, it still impacts purchase behavior. In one interview, a Metro Transit employee shared an anecdote about how some customers take advantage of the transfer policy to ride at reduced

rates[28]. In this example, customers temporarily leave their workplace, heading to the nearest bus stop before the peak period begins at 3:00PM. When the bus arrives, they pay the off-peak fare but don't board the bus. Instead, they ask for the free transfer, which is good for the next 2.5 hours. After receiving the transfer, they return to work for no more than 2.5 hours. When they head back to the bus stop, they use their transfer to board the bus, effectively paying the off-peak price to travel in the peak. This example clearly demonstrates that price sensitive customers are willing to make considerable efforts to avoid paying the peak fare.

Metro Transit Faces Difficulty Predicting Rider Response to Fare Change
To develop an effective peak pricing strategy, transit agencies must accurately predict rider response to fare changes. Metro Transit has struggled in this area for several reasons:

- **Price elasticity model lacks sophistication:** the current model uses general, overly simplistic formulas, characterized as "not very professional" and based on "a lot of gut feeling".[29] Figures have not been updated since 1996.
- **Statistical methods to measure ridership lack accuracy:** Like Port Authority and SEPTA, Metro Transit maintains a barrier-free light rail system. Thus, Metro Transit relies upon periodic census counts to project ridership. In the past, the validity of these projections has been questioned. One audit found that that the agency reported 456,105 more rides than were actually taken from May to November 2006. In other words, 7.5% of the reported rides did not occur (Metropolitan Council, 2007b).
- **Internal IT systems are not integrated:** Metro Transit uses two different systems to record bus ridership data. The first system, tracking smartcard users, captures "time-stamped" data with corresponding route, trip, direction, etc. The second system, tracking all other users (cash, magnetic stripe), is not transactional. The recorded boarding time is usually within +/- 15 minutes of the actual boarding time. When these two systems are integrated on the back-end, they lose some of their detail, making it more difficult to accurately measure ridership across various dimensions such as time, route, direction, etc[30]. One effect is that it can limit studies of ridership patterns at the "shoulder" of the travel distribution, immediately before or after a designated peak period.
- **Major events obscure effect of price on ridership:** Over the last 10 years, Metro Transit has been significantly impacted by economic cycles, service cuts, a transit strike, rising fuel prices, and the launch of light rail service. This makes it very difficult to isolate the impact of price on ridership.

[28] Telephone conversation, Rich Moore, Ridership Analyst, Metro Transit, 12/04/08.
[29] Telephone conversation, Lynn Wallace, Supervisor of Ridership and Revenue, Metro Transit, 02/07/08.
[30] Telephone conversation, Rich Moore, Ridership Analyst, Metro Transit, 12/04/08.

Rising Fuel Prices and Congested Roads Drive Transit Gains

In the past couple of years, certain factors have pushed up driving costs, encouraging some to make the switch from private auto to transit. In 2007, dramatically higher fuel prices and the collapse of the I-35W bridge into downtown Minneapolis increased out-of-pocket expenses and added to commute times. As a result, Metro Transit ridership in 2007 climbed to 77 million trips, up nearly 5% over the prior year and the highest annual total since 1982 (Brewer, 2008). Much of the growth came from passengers taking express buses into downtown Minneapolis and St. Paul. In the first quarter of 2008, ridership continued to show gains, increasing by 7.2% versus the prior year. During this time, light rail ridership grew by 16.4% (Harlow and McAuliffe, 2008). However, the rising fuel prices that pushed citizens towards transit also created challenges for the agency itself. From July 2007 to July 2008, ridership increased by 7.9%, but agency fuel costs increased by 62%, creating a $15 million budget gap, which forced the agency to raise the base fare from $1.50 to $1.75 in October 2008 (Brewer, 2008).

Metro Transit manages one of the most expansive time-based fare structures. However, poor ridership tracking methods and an unsophisticated demand forecast model have made it challenging to understand who is riding the system at a given point in time and how they are most likely to react to a price change. Further, a peak fare component that hasn't kept pace with increases in the base fare and express fare could be problematic. The agency's annual survey delivers valuable insight as to how different customer segments behave differently. For example, few high-income residents use transit during off-peak hours. Middle-income customers are much more likely to use off-peak rail service than off-peak bus service. Peak riders (especially rail) are much less likely to pay cash than off-peak riders. Bus riders in the peak are much less likely to transfer than those traveling in the off-peak. If transit isn't available, off-peak riders are much more likely than peak riders to cancel their trip. Those off-peak travelers who are able to find another suitable means of transportation tend to bike or use taxis much more frequently than if peak travelers are in a similar situation. Future surveys should be designed in such a way that information can be fed into the agency's demand forecast model, improving its ability to accurately predict how different customer segments will respond to future fare policies.

CASE STUDY
KING COUNTY METRO TRANSIT
SEATTLE, WASHINGTON

2007 Key Statistics (Federal Transit Administration)						
Service Area	Annual Unlinked Trips	Annual Passenger Miles	# Buses	Peak-Base Ratio	FTE employees	Fares as % of Operating Funds Expended
2,134 mi^2	113,928,156	572,387,794	1,181	1.64	4,193	17%

Established in 1973, King County Metro Transit (KC Metro) provides services to the 1.7 million people living in King County, Washington. Metro provides mostly bus service, operating a fleet of about 1,300 buses and electric trolleys. To help ease downtown congestion, the agency operates a 1.3-mile electric bus tunnel underneath downtown Seattle, making stops at 5 major destinations. KC Metro offers a paratransit van service and taxi scrip program for disabled residents who are unable to use the ADA-accessible buses. The agency operates the largest publicly owned vanpool program in the country, using more than 600 vans to make 2.9 million trips per year. In 2007, KC Metro began operating a 2.6-mile streetcar line with 11 stops throughout downtown Seattle.

Metro Uses Expansive Time-Based and Limited Distance-Based Structure
KC Metro uses a time-based and distance-based fare structure. Like Metro Transit in Minnesota, KC Metro's peak pricing strategy is more expansive than what is used by PAT and SEPTA. First, KC Metro's peak pricing applies to all regular bus routes, regardless of direction, on Monday through Friday between 6:00AM-9:00AM and 3:00PM-6:00PM. Second, all payment types are impacted by peak pricing. Unlike Metro Transit, KC Metro's peak charges are based on scheduled, rather than actual, arrival times.

KC Metro's service area is carved into two pricing zones. The City of Seattle is considered one zone. The area within King County, but outside the City of Seattle, is a separate zone. A bus trip that crosses the Seattle city limits is charged the two-zone fare. A bus trip that begins or ends on a zone boundary is charged the one-zone fare. The zone-based structure applies only to peak trips. Off-peak fares do not reflect any distinction between one-zone and two-zone trips. Bus trips between 6:00AM-7:00PM in downtown Seattle are always free.

Rising Costs Lead to Four Fare Increases Over Two Years
Organizationally, KC Metro is one of four divisions of the King County Department of Transportation. This division receives a significantly higher level of public subsidy than the other agencies in this report. In fiscal 2007, sales tax

represented 68.1% of operating revenues and 50.8% of capital revenues[31]. Given the relatively elastic nature of sales taxes, KC Metro's budget is especially vulnerable to economic downturns. Although politically sensitive, fare increases are one of the easier ways to raise cash quickly when faced with a budget deficit.

In the early part of this decade, fare prices remained constant. After the 2001 fare increase, King County residents did not see fares rise again until March 2008 when they increased by $0.25 per trip. Transit officials explained that the fare increase was necessary because costs had risen by 37% since the 2001 fare adjustment (The Seattle Times Editorial Board, 2007). By mid-2008, with the economy falling into recession, the agency predicted that they would lose $45 million in sales tax revenue and need another $22 million to cover rising fuel costs. All told, KC Metro faced a $70 million budget gap for fiscal year 2009 (Seattle Post-Intelligencer Editorial Board, 2008). To address the deficit, KC Metro's board of directors enacted a two-stage fare increase over an 11 month period. The first stage, in February 2009, was expected to raise an incremental $9.5 million for that year. The second stage, in January 2010, was expected to raise $22 million more than what would be generated from the original 2008 fare structure. To close the remaining deficit, the agency proposed cost-cutting measures and dipping into reserve funds (Lange, 2008b). Figure 38 outlines recent and future fare increases.

Figure 38

Fare	2001	03/01/08	07/01/08	02/01/09	01/01/10
Peak (1 Zone)	$1.50	$1.75	$1.75	$2.00	$2.25
Off-Peak (1 Zone)	$1.25	$1.50	$1.50	$1.75	$2.00
Peak (2 Zones)	$2.00	$2.25	$2.25	$2.50	$2.75
Off-Peak (2 Zones)	$1.25	$1.50	$1.50	$1.75	$2.00
Youth (6-17 years)	$0.50	$0.50	$0.75	$0.75	$0.75
Seniors/Disabled-Peak	$0.50	$0.50	$0.50	$0.50	$0.75
Seniors/Disabled-Off-Peak	$0.25	$0.25	$0.50	$0.50	$0.75

Similar to trends at Metro Transit and SEPTA, KC Metro's peak price differential has shrunk in recent years. In other words, the percentage difference between peak versus off-peak fares is smaller. For one-zone fares, the peak differential has fallen from 20% (2007) to 17% (2008) to 14% (2009). This pattern holds true for two-zone fares. In recent years, agency officials have priced peak one-zone fares at a $0.25 premium to off-peak one-zone fares. Likewise, peak two-zone fares are priced at a $0.75 premium to off-peak two-zone fares. This decision risks two opportunities:

- Greater ability to shift transit demand to different time periods
- More revenue via a higher peak premium (if peak riders are price inelastic)

[31] Source: 2008 King County Budget, Operating Revenues (Operating Sub-fund); Capital Revenues (Revenue Fleet Replacement Sub-fund + Capital Sub-fund).

Peak Pricing Strategy Incorporates All Fare Media Types
Compared to the other agencies in this report, KC Metro offers fewer types of fare media. A second difference is that all generally available fare media (i.e. excluding youth, seniors, disabled) is part of the peak pricing strategy. These types are as follows:

- **Metro Ticketbooks:** sold at face value per applicable fare level (no discount); only benefit is not having to handle cash
- **Puget Pass (1-month):** sold at various pricing levels (depending if primary travel is peak vs. off-peak, one-zone vs. two-zone); priced at 36 rides - after 36th ride in same month – subsequent trips are effectively free; accepted by KC Metro and 4 other transit agencies in region
- **Puget Pass (12-month):** same pricing structure as 1-month with additional savings because sold at 11-month price.
- **Regional Day Pass:** offers unlimited rides on Metro; restricted to travel on Saturdays, Sundays, and holidays.

Riders using a Puget Pass, priced at the peak one-zone fare level, for a peak two-zone trip, pay the $0.50 difference ($2.50 - $2.00) to the bus operator. Likewise, riders with a Puget Pass, priced for off-peak use, pay the appropriate premium when taking a peak period trip. Because the Puget Pass offers a much smaller price discount than passes sold by comparable agencies in other cities, it's not surprisingly that fewer riders take advantage of such fare media. In 2006, 38% of riders used some type of pass. The remaining customers used cash (47%), tickets (9%) or a reduced fare (11%)[32].

Soaring Ridership Has Hurt Performance
KC Metro's ridership has soared over the past couple of years. In 2007, bus ridership hit an all-time high of 110 million boardings, a 17% increase over the prior year. Since that time, ridership has continued to climb, growing 6% in the first quarter of 2008 and 7% in the second quarter (Lindblom, 2008a; Lange, 2008a). Unfortunately, budget constraints prohibited the agency from making investments to accommodate the growth. As a result, performance has suffered:

- On-time performance[33] (rolling 12-month average) dipped from 80% in the first quarter of 2004 to 74% in the first quarter of 2007 (Roberts, 2008).
- In fall 2007, nearly 50% of bus trips were at least 20% over-capacity. The percentage of passengers forced to stand on the bus grew from 2% (2003) to 7% (2007) (Lange, 2008c).
- Pass-ups[34] increased from 443 in May 2007 to 640 in May 2008. These figures could be under-stated because a recorded pass-up could refer to several pass-ups at several stops along the same route (Lindblom, 2008b).

[32] King County Metro, 2006 Rider/Non-Rider Survey, Note: sum of lines don't add to 100% due to rounding
[33] Buses are considered "not on-time" per the following conditions: arriving 1+ minute earlier than scheduled; arriving 5+ minutes later than scheduled.
[34] A "pass-up" occurs when a bus driver does not stop at a designated bus stop because he/she considers the bus too full to allow any additional passengers to board

Consistent with earlier discussions in this report, a higher peak price premium could influence more peak riders to switch to off-peak hours, reducing the number of pass-ups, lessening over-crowded buses, and improving customer satisfaction. Further, those new peak riders, who would otherwise be passed-up, could off-set those riders switching to cheaper fares in the off-peak, thereby, generating incremental revenue for the agency.

KC Metro Price Elasticity Data Consistent with Earlier Research

For many years, KC Metro has used the same econometric model to predict the impact of future fare increases. Figure 39 displays price elasticities for several fare payment types[35]:

Figure 39

Fare Type	Peak	Off-Peak
Regular Fare (One Zone)	-0.136	-0.204
Regular Fare (Two Zone)	-0.109	-0.163
Puget Pass (One Zone)	-0.091	-0.136
Puget Pass (Two Zone)	-0.073	-0.109
Youth Cash (One Zone)	-0.204	-0.306
Youth Cash (Two Zone)	-0.163	-0.245
Youth Pass (One Zone)	-0.136	-0.204
Youth Pass (Two Zone)	-0.109	-0.163
Senior / Disabled Cash	-0.115	
Senior / Disabled Pass	-0.076	

These results are consistent with earlier studies (Litman, 2006). As expected, bus customers tend to be least price sensitive for travel in peak hours, over greater distances, and with the money-saving Puget Pass. Further, seniors and disabled riders are the least willing to change their travel behavior in response to a fare increase. This could be due to fewer transportation alternatives or the fact that the senior/disabled fare is priced at 20% to 29% of the cost of the regular cash fare. Since March 2008, the fare structure for seniors and disabled riders no longer reflects a price difference between peak fares versus off-peak fares. However, peak pricing may be less relevant for this specific demographic:

- Less likely to be employed than the general population
- Less likely to commute during peak hours
- Less able to switch to other modes in response to higher fares.

Separately, peak pricing might encourage seniors or disabled residents to increase their usage of the more-expensive-to-operate paratransit service. Currently, the paratransit fare is $0.75 per trip, only $0.25 more than the regular senior/disabled fare. It's plausible that seniors who are able to use Metro's ADA-accessible buses might opt to use paratransit if the fare was equivalent to a peak

[35] Source: Raj Cheriel, King County Metro Transit, 01/22/08

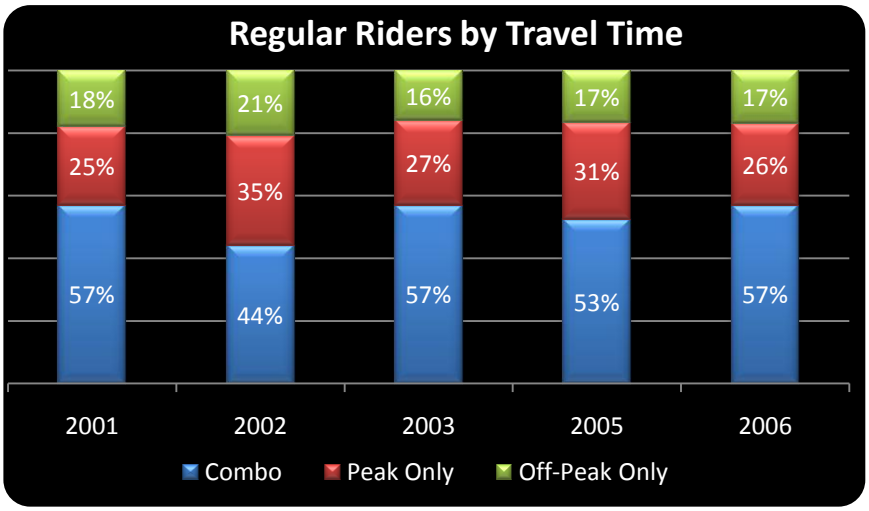
trip on the regular bus. If so, KC Metro would save money by offering these customers an economic incentive to use the regular bus service.

Big Portion of Regular and Infrequent Riders Take Peak and Off-Peak Trips
Since the early 1980s, KC Metro has conducted an annual telephone survey of transit riders and non-riders in the county (Northwest Research Group, 2007). The survey's primary objectives are to:

1. Track customer awareness and perceptions of KC Metro services
2. Identify and track demographic, attitudinal and transit use characteristics of key customer segments: regular riders; infrequent riders; non-riders; work commuters; school commuters

Since KC Metro does not record hourly ridership data, the survey is the best tool to understand ridership patterns by time period. The 2006 survey was used to create the following three graphs[36]. Figure 40 displays time-of-day travel patterns for "regular riders"[37]. Excluding 2002, ridership trends have been relatively stable over time. In each of the last five surveys, significantly more regular riders travel exclusively during the peak than those who only use transit during off-peak hours. Overall, 53.7% of regular riders took a combination of peak and off-peak trips. However, the data does not tell us what percentage of the off-peak trips are non-discretionary (commute to work/school) versus discretionary (social, shopping, entertainment). Perhaps the majority of these riders use transit as their primary transportation mode, taking all types of trips at all times of day. Conversely, it's plausible that the majority tends to use transit for the work-related commute, but has the flexibility to travel to and from work at off-peak hours.

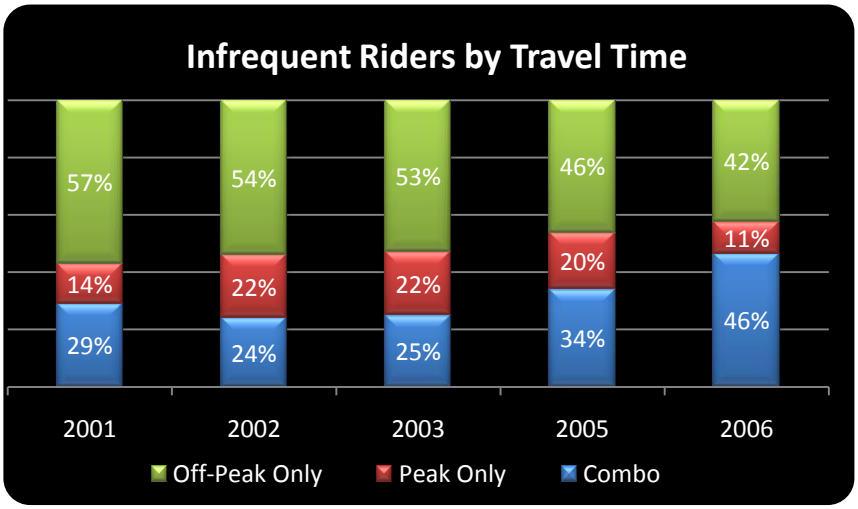
Figure 40



[36] N = 2,450 King County residents; Survey results equally stratified by 3 geographic regions and 2 customer segments: regular riders versus infrequent riders/non-riders
[37] Regular riders are defined as residents 16 and older who made five or more transit trips in the last 30 days excluding riders entirely in the Seattle Ride Free Area

Figure 41 displays ridership patterns by time period for "infrequent riders"[38]. Over time, a growing percentage of infrequent riders use transit for a combination of peak and off-peak trips. In 2001, 29% of infrequent riders traveled during both periods. By 2006, that statistic had grown to 46% of riders. Because infrequent riders take less than 5 trips per month, one might assume those trips are not work related. This customer segment may limit transit usage to very specific purposes. Thus, it's plausible that some infrequent riders may be less price sensitive because they attach a special significance to the trip. For example, a customer taking transit to a special event in downtown Seattle might not consider the peak price differential when deciding the best time to board the bus. Not surprisingly, a relatively small percentage of infrequent riders travel exclusively during the peak. Peak trips tend to be work-related trips. Riders commuting during peak hours will tend to use the system on a regular basis, thus, be categorized as regular, rather than infrequent, riders.

Figure 41



Bus Ridership More Peak Driven than Auto Travel

Figure 42 shows how commute times vary by mode. This survey defines commuters as those who work or attend school outside the home three or more days per week. Clearly, a greater percentage of bus riders commute exclusively during the peak than any other group. This suggests that transit users tend to have a more structured work schedule, aligned with traditional peak periods. Conversely, twice the percentage of drivers as bus riders commutes during a variety of time periods with no predictable pattern. In this case, the cause-effect relationship is unclear. It's possible that commuters with unpredictable work schedules may prefer the relative convenience and reliability of driving. However, it's just as plausible that workers choose to commute at a variety of time periods because their car more easily affords that opportunity.

[38] Infrequent riders are defined as residents 16 and older who made 1 to 4 transit trips in the last 30 days excluding rides entirely in the Seattle Ride Free Area

Figure 42

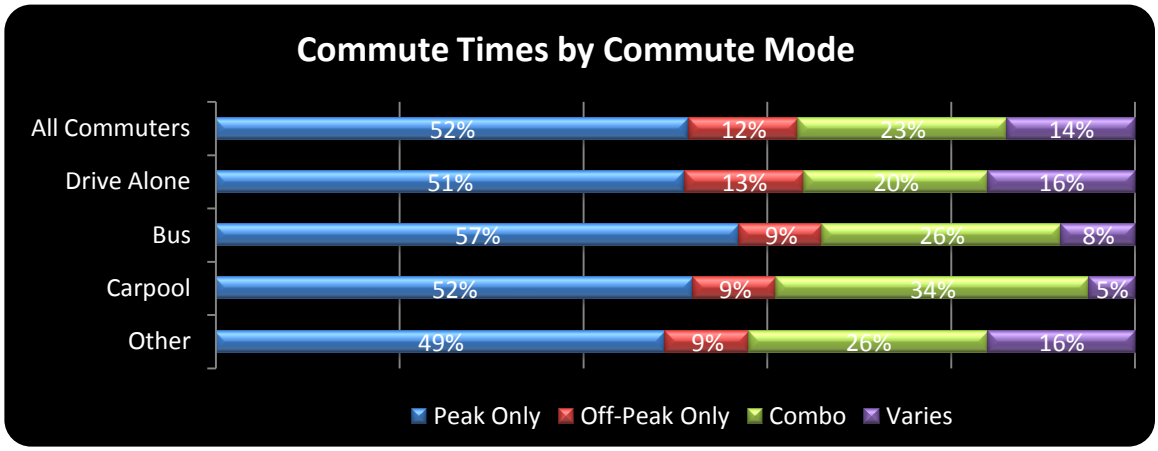
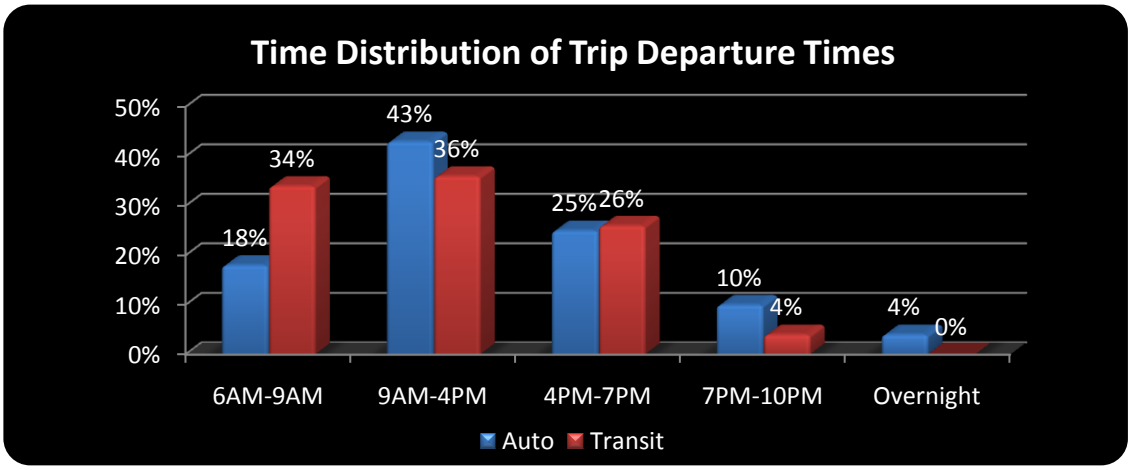


Figure 43 expands upon the idea that consumers prefer to drive during off-peak hours when transit service operates at lower levels. The graph shows auto travel as less peak-driven. For example, 14% of auto trips are taken after 7pm compared to 4% of transit trips (Puget Sound Regional Council and Washington State Department of Transportation, 2007). By creating a greater price distinction between peak fares versus off-peak fares, KC Metro could reshape the travel distribution, making it less peak-driven. Simply lowering the off-peak fare could encourage new ridership and convince some existing peak riders to switch time periods. However, the degree of reshaping is not likely to be great. As discussed in the literature review, even dramatic off-peak discounts do not often generate a big jump in new ridership.

While the region's transit trips are peak driven relative to auto trips, they are much less peak driven compared to other transit systems in this report. For example, 43% of the Seattle region's transit trips are taken by transit compared to SEPTA's (Regional Rail) 63% and Metro Transit's 50%. KC Metro's more expansive peak pricing strategy could be a major contributing factor to this effect.

Figure 43



KC Metro uses a more expansive peak pricing strategy that impacts all fare payment types. As a result, fewer riders use passes as a way around the peak fare. This enhances social equity because there is less chance of low income riders, who tend to pay cash, cross-subsidizing more affluent, pass-using riders. This strategy may also contribute to a ridership pattern that is less peaked than other systems in this report. However, growing ridership and a shrinking peak price differential is straining peak capacity, hurting performance and reducing customer satisfaction. Metro's price elasticity data suggests that a higher peak price premium could reduce some of the strain on peak capacity without hurting total revenue.

CASE STUDY
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
WASHINGTON, D. C.

2007 Key Statistics (Federal Transit Administration)						
Service Area	Annual Unlinked Trips	Annual Passenger Miles	# Buses / # Train Cars	Peak-Base Ratio	FTE employees	Fares as % of Operating Funds Expended
692 mi^2	411,598,592	2,021,233,681	1,504 / 972	Bus (2.4) / Train (2.9)	10,000	38%

The Washington Metropolitan Area Transit Authority (Metro) serves 3.5 million residents and hundreds of thousands of visitors. Metro operates the country's second largest rail network with 86 stations connected by 106 miles of track. The agency operates the fifth largest bus network, including a fleet of 1,500 buses dispatched to 12,000 stops along 340 routes. The Authority encompasses 8 jurisdictions, including the District as well as cities and counties in Maryland and Virginia.

Metrorail Uses Time-Based and Distance-Based Pricing

Metro's rail service (Metrorail) uses a time-based and distance-based fare structure. Peak periods are relatively long, defined as weekdays from 5:00AM-9:30AM and 3:00PM-7:00PM, and Saturday and Sunday mornings between 2:00AM-3:00AM. The distance-based structure is more complicated. During the peak period, all riders are charged a flat rate (boarding charge) for the first 3 miles of the trip. For longer trips, riders pay a rate per mile between the third and sixth mile. After 6 miles, a lower rate applies. However, the total fare price is capped at $4.50 per trip, which is less than what the longest-distance trip would cost based on the fare formula. During the off-peak, a different formula applies. One of three flat rates is used, depending on the total distance of the trip: 0-7 miles; 7-10 miles; and 10+ miles. The total off-peak fare is capped at $2.35 per trip.

Metrobus Uses Service-Based Pricing

Metro's bus service (Metrobus) uses a service-based fare structure but does not differentiate fares by time period or distance. Prior to December 1981, Metrobus charged slightly higher fares during peak hours. However, Metro officials contacted for this report did not know why the agency eliminated peak pricing. In June 1999, Metrobus implemented service-based pricing, charging higher fares on express bus routes. Because Metrobus does not utilize peak pricing, this case study will not focus on its operation.

Metro Relies More on Rail Fares than Bus Fares

Unlike many U.S. transit agencies, Metro does not enjoy a dedicated public funding source, such as a fuel tax, sales tax, or property tax. Instead, Metro must

lobby for annual appropriations from the federal government, the District, and surrounding counties. Because of funding uncertainty, Metro tends to rely more heavily upon fares than other transit systems. In fiscal year 2009, total fares are projected to cover 48.7% of operating costs (Washington Metropolitan Area Transit Authority [WMATA], 2008).

When setting fare policy, Metro officials have sought to balance two competing goals: comprehensive service and accessible pricing. To that end, Metro has kept bus fares artificially low (WMATA, 2006). This is for two main reasons:

- As the Metrorail network has expanded, Metrobus has increasingly served as a feeder service to rail
- Metrobus customers tend to earn less income and have fewer transportation options than Metrorail customers

In fiscal year 2009, Metrobus fares will cover 22.2% of operating costs and public subsidy will pick up 69.6% of costs. Other system-generated revenue will make up the remainder. In contrast, Metrorail fares will cover 66.2% of costs with public dollars paying 16.2% of costs (WMATA, 2008). This example illustrates how political considerations can heavily influence a transit agency's fare structure. Clearly, Metrobus customers benefit from a relatively large public subsidy of their trip. Of course, Metrobus passengers do not enjoy the same level of service as rail customers: slower average speeds and less frequency. However, even the longest peak bus trip is cheaper than the shortest peak rail trip. It would be interesting to study how different Metrobus customers respond to fare changes. More specifically, examining how customers who use Metrobus as a feeder to rail differ from those who use Metrobus as their sole transit provider.

Metro Proposed Several New Pricing Schemes to Close Budget Gap
Despite raising fares in 2003 and 2004, Metro faced a projected $116 million budget shortfall in 2008 due to rapidly increasing health care charges and union-negotiated raises (Sun, 2006). To address the budget crisis, Metro proposed several new pricing schemes (Sun, 2007a):

- **Charge higher fares for payment by cash versus SmarTrip[39]:** Processing cash payments drives up operating costs due to greater need for personnel, higher equipment maintenance costs, and increased risk of employee theft.
- **Implement a higher boarding charge on Metrorail for peak trips versus off-peak trips:** Historically, Metro applied the same initial boarding charge, regardless of time period, for short-distance trips up to 3 miles. Officials hoped that lower off-peak charges would encourage incremental trips in off-peak hours.

[39] SmarTrip is WMATA's permanent, rechargeable smartcard

- **Levy a $0.35 surcharge on peak riders who pass through any of the 19 downtown Metrorail stations:** These customers place the greatest strain on infrastructural capacity. Further, they receive the greatest benefit by taking transit through the region's most congested corridors. Thus, they should bear a greater financial burden to enjoy this benefit.
- **Develop a policy of programmed fare increases:** Automatic fare hikes based on increases in a cost index linked to labor, fuel, or other factors. Fare increases would be capped to eliminate steep increases and to maintain a certain cost to revenue ratio.
- **Offer a discount to reverse commuters during peak periods**: While capacity is strained for morning routes into downtown, excess capacity exists for many routes leading away from the city's core.

Political Factors Influence Fare Policies

These ideas were politically sensitive. During budget hearings, many stated that it was unfair to offer cheaper boarding charges to tourists and infrequent riders who typically use the system in the off-peak hours (Sun, 2007a). The competing interests of different Metro board members made it more difficult to reach resolution on a new fare structure. District members, representing many low-income residents who rely more heavily upon Metrobus, were especially focused on limiting the growth of bus fares. Meanwhile, suburban representatives fought to keep parking fees and rail fares low (Sun, 2007c). Suburban commuters, with longer-distance trips and fewer viable modes, felt that higher peak fares targeted them because they were least able to change their travel behavior. Recall that the relatively wide peak periods make it very difficult for residents to shift their work-related trip to the off-peak (Sun, 2007a). However, suburban commuters still realized significant economic benefits from using transit. A 2006 study showed that suburban commuters, parking their car at a Metro lot, and taking the train downtown, pay about 70% of what it would cost for them to drive their own car downtown and park (Pearlstein, 2006).

Peak Price Differential Increases Under New Fare Structure

In December 2007, Metro's board adopted a few of the earlier proposals, increasing fares for the first time in four years. The peak period boarding charge rose from $1.35 to $1.65. The mileage rate for both tiers increased as well. The maximum peak fare increased by $0.60 to $4.50 per trip. Off-peak fares were unchanged (Sun, 2008b). Over the last decade, Metro is the only agency in this report to increase the peak price differential, achieving a wider variance between the peak and off-peak fare. The current fare structure, effective 1/06/08, is detailed in Figure 44. Based on the structure, the peak fare for an 8 mile trip on Metrorail would cost approximately $2.94. The calculation is as follows:

1. Boarding charge (0-3 miles): $1.65
2. Tier 1 (3-6 miles): $0.81 [$0.27 X 3]
3. Tier 2 (6-8 miles): $0.48 [$0.24 X 2]
4. $1.65 + $0.81 + $0.48 = $2.94

The same 8 mile trip during the off-peak period would cost $1.85. Senior citizens (65+) and the disabled pay one-half the regular price.

Figure 44

	Metrorail: Peak Period			Metrorail: Off-Peak Period			Metrobus: Cash Fare	Metrobus: SmarTrip Fare
Fare	Boarding Charge (0-3 mi.)	Tier 1 (3-6 mi.)	Tier 2 (6+ mi.)	Boarding Charge (0-7 mi.)	Tier 1 (7-10 mi.)	Tier 2 (10+ mi.)		
Local	$1.65	$0.27/mi	$0.24/mi	$1.35	$1.85	$2.35	$1.35	$1.25
Express	-	-	-	-	-	-	$3.10	$3.00

Figure 45 compares peak versus off-peak pricing under the previous (prior to 01/06/08) fare structure and Figure 46 compares the same effect under the current fare structure. Each chart displays pricing for the same trip, which follows the entire length of Metrorail's Orange Line. The contrast between the two charts is stark. In Figure 45, the two lines are relatively close across much of the chart. Starting from the westernmost station, and traveling to the next closest station, the fare is the same. At its most extreme, the peak fare is 66% higher than the off-peak fare.

Figure 46 tells a different story. The off-peak fare line is unchanged. However, the new peak fare line rises much more rapidly, creating greater distances between the peak and off-peak data points. The slope of the peak fare line is 0.105 in Figure 45 and 0.096 in Figure 46. From the westernmost station, the peak fare for the shortest distance trip costs 22.2% more than the off-peak fare. At its most extreme, the peak fare is 91.5% higher than the off-peak fare. As discussed previously, this new pricing structure is likely to have two major effects:

1. Increase total revenue, primarily from non-discretionary travelers with little to no flexibility to the start of their workday
2. Encourage discretionary travelers to ride during the off-peak period

Maximum Fare is Reached Sooner Under New Fare Structure

These two charts show another difference. Because of the maximum fare policy, the difference between the peak and off-peak fares is reached before traveling the entire length of the Orange Line. Under the old structure, the maximum differential is $1.55, reached after visiting the 22nd station along the line. Under the new structure, the maximum differential is $2.15, reached after visiting the 16th station. The new peak fare rises much more rapidly as the trip covers greater distances. For example, the new peak price differential for the longest trip (25 stations) is $0.60 ($2.15-$1.55) greater than under the old fare structure. However, for a shorter distance trip (15 stations) the new peak price differential is $1.50 ($2.10-$0.60) more than under the old structure. As a result, it could be valuable to

research whether the new fare structure discourages shorter-distance trips in peak hours.

Figure 45

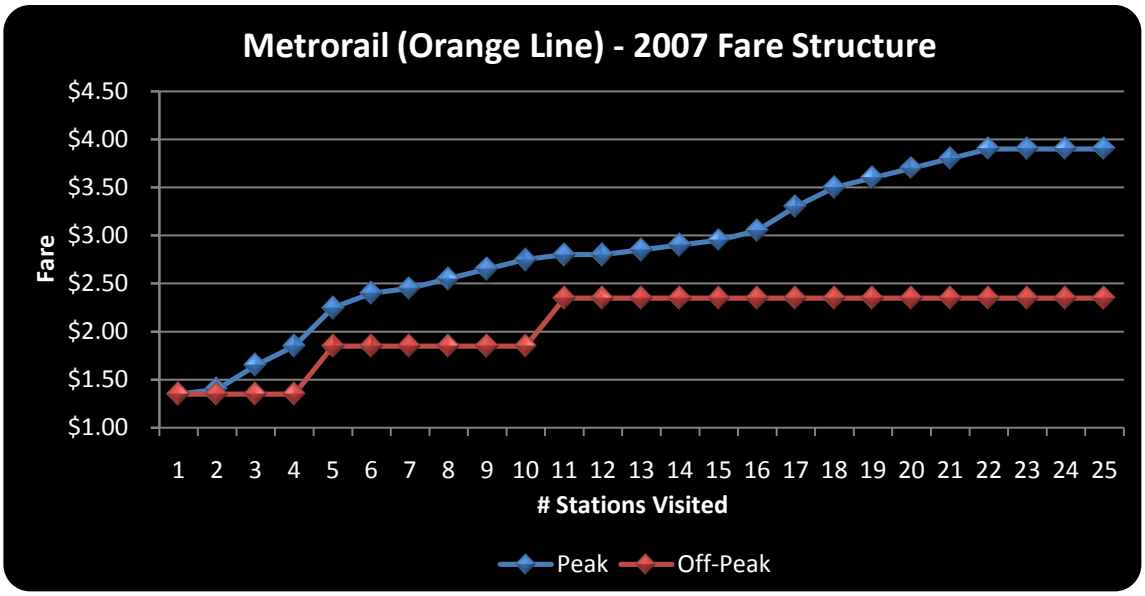
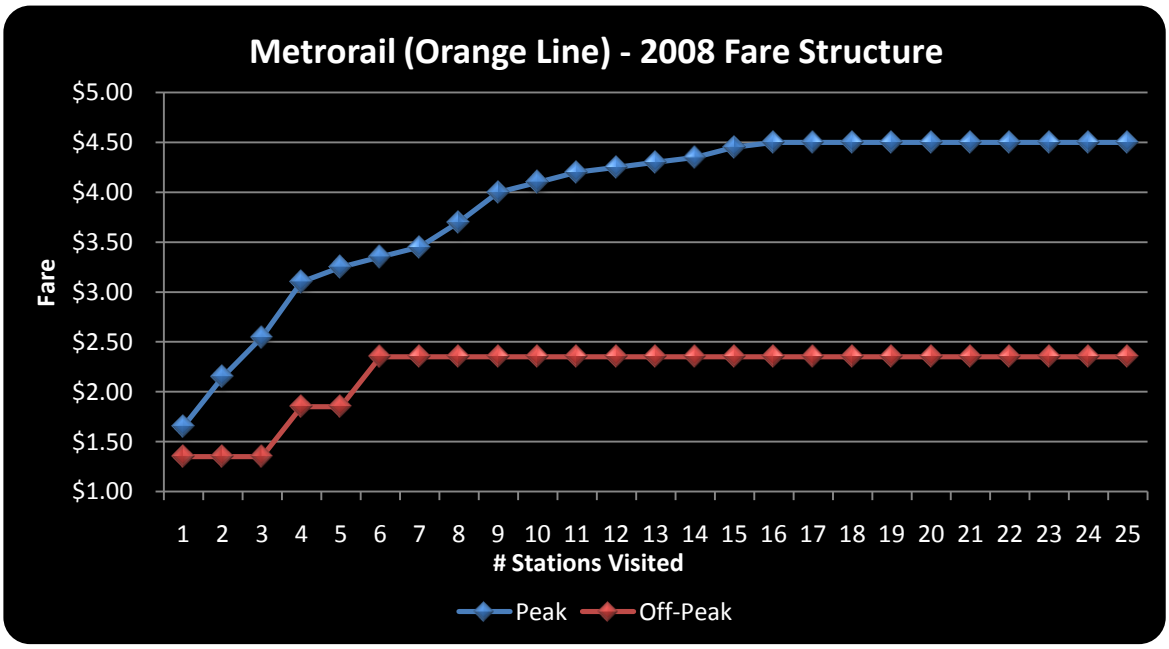


Figure 46



Metro Adopts Higher Bus Fares and Programmed Fare Increases

In December 2007, Metro's board adopted another earlier proposal, raising cash bus fares by $0.10 (+8%), but keeping bus fares constant for those paying by

SmarTrip. As stated previously, a disproportionate number of Metrobus customers are low-income earners. To provide some relief, Metro distributed 50,000 SmarTrip cards to low-income riders, waiving the $5 purchase price. Despite a relatively small increase, riders responded by migrating from cash to SmarTrip to realize the $0.10 savings. After the first three months of the increase, SmarTrip penetration increased from 20% to 26% (Sun, 2008b). At the same meeting, the board chose to institute a programmed fare increase. Starting in July 2010, automatic fare adjustments for Metrorail will be made every two years. The adjustment will be linked to a biennial increase in the Consumer Price Index from the last two years (Sun, 2007e).

Metrorail Ridership Grows in Each Sector of Network

Despite capacity constraints and fare increases over the last few years, Metrorail ridership has continued to climb. In the five years between spring 2002 and spring 2007, ridership increased within each sector: District (+17%), Maryland (+8%), and Virginia (+4%). Following the afternoon peak, when fares are cheaper and trains are less crowded, ridership grew a whopping 22% over the 5-year period (Sun, 2007b). More recently, Metrorail has gained ridership due to rising fuel prices and improved on-time performance.[40] Average weekday ridership grew in each of the first three months of the fare increase compared to the previous year: January (+6%); February (+4%); March (+3%) (Sun, 2008b).

Metrorail Peak Ridership Drawing Closer to Maximum Capacity

Eventually, Metro will not be able to accommodate new peak ridership without major capital projects that create new tunnels and rail lines. Metrorail planners have established a “peak primary standard”, which states that ridership should not exceed an average of 120 passengers per car (ppc) passing through the maximum load point in the peak direction in the peak one hour on each line. Planners have identified the 120 ppc mark as the point at which customers will refuse to board the train and be left behind on the platform. Based on this standard, planners calculate maximum capacity as 26 eight-car trains, holding 120 passengers per car, passing through each maximum load point at the rate of one every 136 seconds. In 2001, planners estimated that the Orange Line would reach full capacity by 2020. At that point, it would begin to lose its share of the total regional trips (WMATA, 2001).

Higher ridership, budget woes, deteriorating infrastructure, and equipment failures affecting 50% of the 1,070 car fleet has hurt service levels. During the morning peak, on-time performance dropped from 90% (November 2006) to 85% (November 2007). The afternoon peak fared even worse, falling from 87% to 82% (Sun, 2008a). To save money and reduce wear and tear on the system, Metro reduced service from 6-car trains to 4-car trains during off-peak hours, starting in

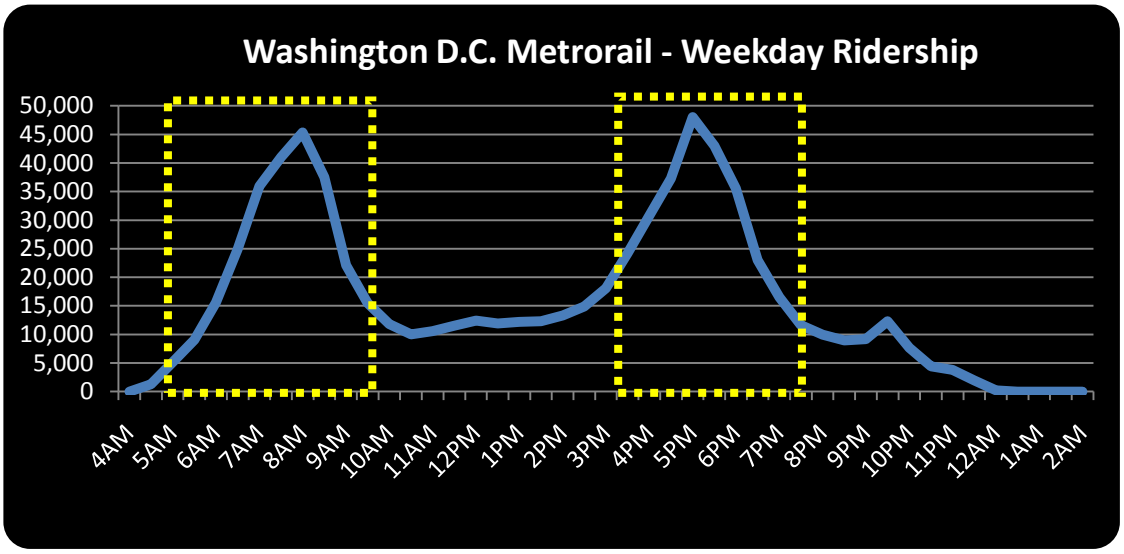
[40]WMATA defines Metrorail on-time performance as: Measured during peak service (AM/PM), identifying percentage of trains on each line end-to-end within a 2 minute headway deviation and measured mid-day non-peak and late night non-peak within a 50% headway deviation. WMATA calculates Metrorail on-time performance as: (# of Metrorail station arrivals – # of headways with >2 min. deviation or 50% headway deviation) / # of Metrorail station arrivals = Metrorail On-Time Performance End-to-End.

November 2007. When at capacity, 4-car trains hold 720 people and 6-car trains hold 1,080 passengers. However, public outcry was so great that Metro abandoned their initiative after three weeks. Reversing course, Metro began operating 6-car trains on weekends and running 6-car trains and a limited number of 8-car trains during the midday off-peak (Sun, 2007d). Since early 2008, Metro has added 30 more rail cars to peak period service with plans to operate 8-car trains (the maximum train length) on 50% of peak trains across all 5 subway lines by spring 2009 (Sun, 2008a). At the expense of higher fares, Metro's increased peak service has improved on-time performance. Starting in December 2007, on-time performance increased for 5 consecutive months, reaching the 95% mark in March for the Red and Orange lines (Sun, 2008b). Other studies suggest an institutional resistance to cutting service, even when ridership is low, has meant that Metro sometimes diverts scarce resources to routes that offer relatively little benefit. In this case, operational efficiencies could enable Metro to offer future increases in peak period service without the need for higher fares.

"Peak of the Peak" Already at Full Capacity on Some Runs

Figure 47 shows the Metrorail ridership distribution for a typical weekday in May 2005. More specifically, it charts the number of riders entering the system within 30 minute intervals. Peak periods are represented by the yellow boxes. In the graph, 69.2% of total ridership fell within the peak periods. Morning entries peak between 8:00AM-8:30AM when about 45,300 passengers enter the system. This statistic is roughly 10.4% higher than the second busiest morning period, between 7:30AM-8:00AM, when roughly 41,100 customers enter the system. At the height of morning ridership, there is a period of about 75 minutes when at least one part of the system is at maximum capacity as defined by the peak primary standard. During the afternoon rush, the graph peaks between 5:00PM-5:30PM when 48,000 customers enter the system, an 11.7% increase over the next highest time period of 5:30PM-6:00PM. At the height of afternoon ridership, some parts of the system reach maximum capacity for as long as 90 minutes (WMATA, 2001).

Figure 47



One of the greatest challenges to Metro planners is that passenger counts vary significantly throughout the peak period. In the peak hour, ridership on a particular route may reach the peak primary standard but may range from 60 ppc to 160 ppc within a smaller timeframe. A restructured peak pricing strategy may enable an agency to increase daily ridership without adding new service hours. According to Nat Bottigheimer, Metro's Chief Planner, if rail riders spread out their peak trips, instead of crowding into the "peak of the peak", Metro could accommodate an additional 140,000 trips, increasing peak capacity by 27.5% (Sun, 2008b). One solution might be to narrow the time period in which higher fares apply, encouraging riders to migrate to the shoulders of the peak. Another solution might be to create two-tiered peak pricing, raising the fare for those who choose to travel during the "peak of the peak" or the 60-minute block of time that represents the greatest number of passenger entries.

Majority of Peak Commuters Exit at "Core" Station in Morning

As mentioned earlier, Metro board officials had considered offering a reverse commute discount to stimulate new ridership on under-utilized sections of the rail network. Figure 48 displays origination and destination data during the morning peak of a typical weekday in May 2006 (WMATA, 2006). Metrorail commuters tend to exit at the "Core", representing an aggregate of centrally located stations in the District and nearby Virginia suburbs. During the morning peak, 74% of riders enter the system in Arlington County and exit at one of the core stations. Conversely, only 21% of peak riders start their day by entering the system in the core and exiting at one of the four outlying counties. The risk in offering a reverse-commute discount is that it might not attract enough new riders to off-set the revenue loss from the reduced fare. If suburban work locations are not well-connected to Metrorail, even a deep discount may not be enough to get potential customers to switch to transit. Further, transit officials would have to carefully define what is considered a reverse commute. For example, how would you

categorize a trip that begins in the Maryland suburbs, travels through the District, and ends in an outlying Virginia suburb? While the passenger enters and exits the system at a non-core station, he/she still passes through the core, defeating the purpose of generating new ridership away from heavily utilized sections of the rail network.

Figure 48

AM Peak	EXIT						
ENTER	Core	D.C.	Montgomery County	Prince George's County	Alexandria	Arlington County	Fairfax County
Core	63%	15%	7%	3%	2%	8%	3%
District of Columbia	60%	19%	8%	5%	2%	4%	2%
Montgomery County	69%	11%	13%	2%	1%	4%	1%
Prince George's County	65%	15%	6%	4%	2%	6%	2%
Alexandria	68%	9%	2%	1%	5%	10%	4%
Arlington County	74%	10%	3%	1%	3%	6%	4%
Fairfax County	72%	7%	2%	1%	4%	12%	2%

Every five years, Metro conducts a comprehensive survey of its rail passengers. Over a five week period, more than 300,000 survey cards are distributed to customers entering the Metrorail system at all 86 stations. Customers can mail the self-addressed, pre-paid survey card or they can drop it off at collection boxes located outside the station manager's kiosk.

Peak Riders Have Access to More Private Vehicles

The 2007 survey results are consistent with findings in this report's literature review. Figure 49 clearly shows that peak rail riders tend to come from households that own more vehicles, providing them a convenient alternative to transit. While peak riders may still choose to absorb fare increases, they are more likely to have more alternatives than off-peak riders.

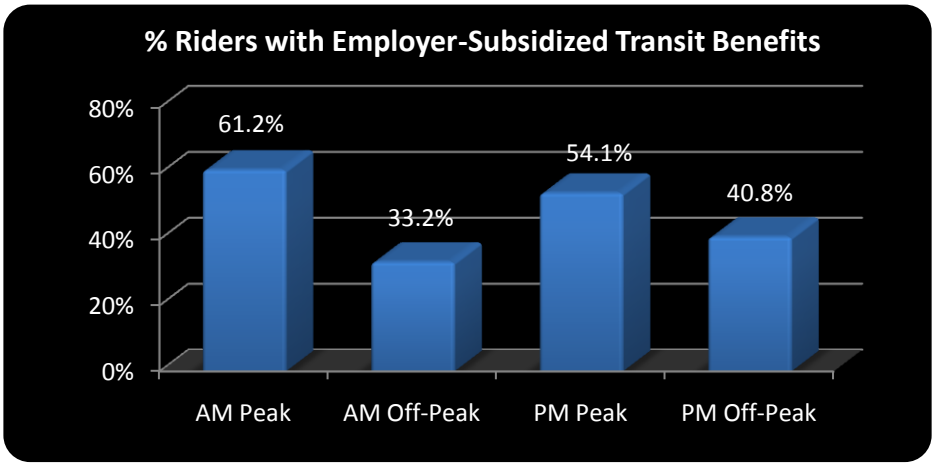
Figure 49

	# Autos Owned			
Type	0	1	2	3+
Peak Riders	17%	37%	33%	13%
Off-Peak Riders	26%	36%	28%	10%

Peak Riders More Likely to Receive Employer-Subsidized Transit Benefits

Figure 50 charts the percentage of riders who use employer-subsidized fare media. As expected, peak riders are more likely to take advantage of discounted fare media offered through their employers. Nearly twice as many morning peak riders use employer-subsidized benefits as morning off-peak riders. Metro offers SmartBenefits®, a convenient web-based program that lets employers assign the dollar value of employees' monthly commuting benefit directly to the employees' SmarTrip cards.

Figure 50



Suburbanites Use Transit in Peak, Leave Off-Peak Ridership to City Dwellers
Based on survey results, Figure 51 shows how modes of access and egress to Metrorail differ by time period. During the morning peak, most customers walk, drive, or take Metrobus to access the rail system. Once these customers reach their last rail stop, an overwhelming majority (84.8%) will walk to their final destination. There are stark differences between the modes of access for the morning peak versus the morning off-peak. During the morning off-peak, about twice as many walk or take a taxi to the nearest Metrorail station. A much smaller percentage of customers use private auto to access the system whether by driving alone, riding with someone, or being dropped off at the station. This suggests that morning off-peak riders are more likely to be living near one of the core stations, which are more easily reached by walking or taxi than suburban locations.

As discussed previously, peak ridership tends to be directional, with the majority of riders exiting at one of the core stations during the morning commute. Thus, it's not surprising that the vast majority of customers access Metrorail by walking after they leave their workplace at the end of the day. There is little change between the percentage who walk to Metrorail during the afternoon peak (82.2%) and those who access the system after the peak period (78.8%). At the end of the day, travel behavior by mode of egress differs significantly for those riding during the PM peak versus the PM off-peak. During the PM peak, a much smaller percentage of customers walk to their final destination and a much greater percentage drive their car or transfer to a non-Metro bus or rail service after leaving Metrorail. This suggests that suburbanites are much more likely to use Metrorail during peak versus off-peak hours. This is consistent with the theory that many riders limit transit usage to long-distance peak hour trips, switching to private auto for shorter, off-peak trips. Given the fact that 27% of afternoon peak customers transfer from Metrorail to another transit provider, it's critical that regional providers coordinate planning activities to develop well-connected transit nodes.

Figure 51

	Mode of Access			
	AM Peak	AM Off-Peak	PM Peak	PM Off-Peak
Walk	33.3%	64.9%	82.2%	78.8%
Drove Car and Parked	29.3%	11.9%	3.6%	2.7%
Metrobus	14.9%	10.7%	5.9%	6.8%
Dropped Off by Someone	9.3%	4.7%	2.5%	5.2%
Non-Metro Bus Service	7.5%	5.3%	4.8%	4.1%
Non-Metro Rail Service	3.8%	0.9%	0.3%	0.8%
Rode with Someone who Parked	1.0%	0.4%	0.2%	0.4%
Bicycle	0.7%	0.7%	0.3%	0.6%
Taxi	0.2%	0.4%	0.1%	0.5%
TOTAL	100.0%	100.0%	100.0%	100.0%

	Mode of Egress			
	AM Peak	AM Off-Peak	PM Peak	PM Off-Peak
Walk	84.8%	72.6%	38.9%	56.9%
Drive Car	2.3%	9.6%	26.5%	16.4%
Metrobus	6.7%	9.2%	15.1%	13.0%
Picked Up by Someone	0.9%	1.8%	5.9%	5.8%
Non-Metro Bus Service	4.5%	4.7%	8.2%	4.4%
Non-Metro Rail Service	0.3%	1.0%	3.7%	0.6%
Ride with Someone who Parked	0.1%	0.3%	0.9%	0.5%
Bicycle	0.2%	0.4%	0.6%	1.1%
Taxi	0.2%	0.5%	0.3%	1.5%
TOTAL	100.0%	100.0%	100.0%	100.0%

Peak Riders Take Longer Distance Trips

Metrorail's distance-based fare structure requires customers to use their fare card to enter and exit the system. As a result, Metro is able to record trip distance for each passenger. Figure 52 displays morning peak trips by distance and Figure 53 covers morning off-peak trips. Consistent with the literature review, peak riders tend to take longer-distance trips than off-peak riders. During the morning peak, 21% of passengers rode for 13 miles or longer. In contrast, 13% of off-peak riders took trips that were at least 13 miles. Thus, peak riders tend to consume more transit service by enjoying longer trips.

Figure 52

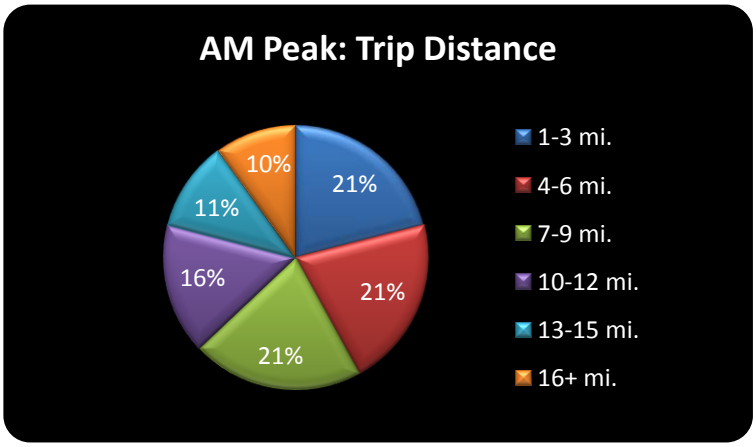
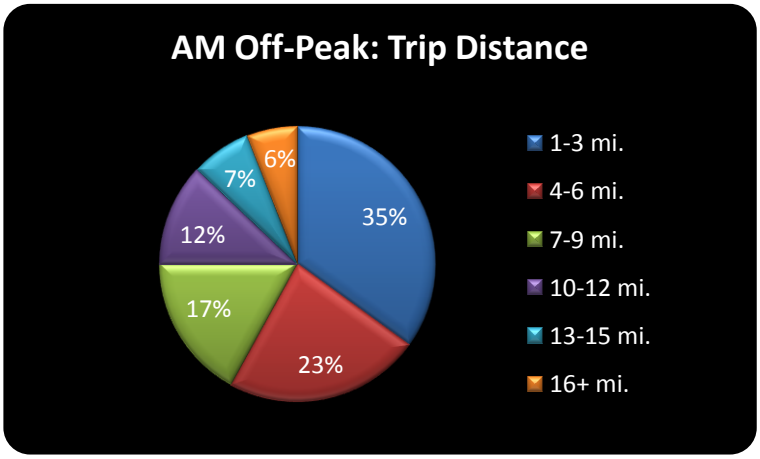


Figure 53



Compared to the other agencies in this report, Metrorail's peak pricing strategy has enormous scale and scope. WMATA uses the most expansive definition of peak periods and no fare media (except for seniors/disabled) is immune to the peak fare. Thus, about 70% of all daily riders are paying the peak fare. Further, Metro is the only agency in this report to increase the peak fare differential in recent years. Metro relies heavily upon people paying the peak fare for a couple of important reasons. First, a lack of a dedicated public funding source means that the agency places greater importance on fares, seen as the only predictable revenue stream from year to year. Second, relatively high rail fares allow the agency to heavily subsidize the relatively cheap flat-fare structure on Metrobus.

In the past year, Metro increased peak rail fares, leaving off-peak fares unchanged. This has shifted more of the burden to peak riders, who tend to consume more transit service (longer-distance trips) and receive more employer-subsidized transit benefits. Despite recent increases in peak level service (more 8-car trains), the system is already at maximum capacity on certain runs within the

“peak of the peak”. Eventually, new capital projects will be needed to accommodate growing demand. Until then, a reconfigured fare structure and more flexible work schedules that shifts demand away from the “peak of the peak” could provide some much needed relief.

DISCUSSION

Strong Case Study Evidence for Service Effectiveness and Social Equity
In the literature review, the author cited research which suggested that a transit agency might realize three major benefits by using a time-based fare structure. First, the agency could enhance service effectiveness. In a flat-fare environment, consumers are discouraged from taking short trips on transit because of the relatively high cost per mile. Cervero (1981) found that people take a higher proportion of short trips in the off-peak hours. Transit runs during the off-peak tend to offer excess capacity and to have low capital costs. An agency could use off-peak discounts to attract riders without the need to expand capacity or to substantially increase operating costs. In the case study of Washington D.C.'s Metrorail, 21% of peak morning riders traveled 3 miles or less while 35% of off-peak morning riders traveled 3 miles or less.

Second, peak pricing can potentially improve social equity across transit riders. Luhrsen and Taylor (1997) reported that low-income riders, without access to an automobile, tend to take a higher proportion of local bus trips, shorter trips, and non-work trips, which are more likely to occur during off-peak hours. In a flat-fare structure, this relatively low-cost service is over-priced. Thus, low-income riders pay more per mile of service consumed, effectively cross-subsidizing the longer, peak period trip of higher-income riders. Further, low-income riders lack the disposable income to purchase unlimited ride passes and other stored value cards that offer the deepest fare discounts. In the case study of Metro Transit, 30% of peak rail customers came from households earning less than $40,000 (2006 dollars). However, this statistic increased to 48% for off-peak rail customers. Additionally, 43% of cash-paying local bus customers traveled during the peak. The remaining 57% of local bus riders, who used cash, traveled during the off-peak.

Past Research on Peak Pricing Suggest Cost Efficiency Gains in Many Areas
Third, research suggests that peak pricing can increase cost efficiency because the peak fare is related to the marginal cost of the service. These efficiencies can be found in several areas:

- **Increase cost recovery:** Peak travel is relatively price inelastic so a fare increase during peak hours will generate more total revenue. The increased revenue from peak riders will more than off-set the revenue loss from those who switch to the off-peak or stop riding altogether. Aaron Golub argues that transit agencies with a flat-fare structure lose potential revenue. Because expensive trips (peak, long distance) are so subsidized, they are over-used, and agencies see an increase in the number of heavily discounted trips (Nelson, 2006). Conversely, cheap trips (off-peak, short

distance) are so over-priced, they are under-used, and agencies see a decrease in the number of trips where customers overpay.

- **Raise passenger productivity:** By stimulating more short-distance trips, peak pricing can increase passenger productivity. Transit authorities increase revenue when multiple customers use the same seat (or space) over the course of the run. The faster an agency can turn over a seat on the same run, the higher the revenue per service mile. Flat fares tend to stimulate over-use of long-distance trips, limiting turnover, and forcing agencies to add costly capacity if they want to generate more ridership.
- **Reduce operating costs:** Peak pricing reduces the difference between peak and off-peak service demand. Thus, transit agencies rely less heavily upon "split shifts" and part-time work to fill high labor demand during peak hours. This type of labor is expensive for transit agencies. Full-time employees often work "split shifts" and union rules typically dictate that agencies pay out split-shift premiums, overtime, or guarantee pay. Part-time workers tend to receive less pay, fewer benefits, and the least desirable work schedules. As a result, part-time workers have higher rates of attrition and absenteeism. The absenteeism rate for bus operators is as much as 3 times that of other blue-collar workers. Often, full-time employees pick up shifts from absent part-time employees at time-and-a-half or better wages. Replacement bus drivers are often less familiar with routes and traffic patterns which can lead to service delays and higher accident costs (TCRP, 1999). One study of the San Francisco Municipal Transportation Agency found that a high rate of absenteeism among the agency's mechanics and maintenance workers contributed to an equipment failure rate that was twice that of similar equipment operated by agencies in Boston, Seattle, and New York (Byrne, 1998).
- **Reduce capital costs:** Peak pricing can have a smoothing effect on the travel distribution. As a result, transit agencies can more efficiently manage their fleet, reducing the inventory of rolling stock. On average, the remaining inventory is used more often, increasing revenue service per vehicle. This smoothing effect also reduces demand at high congestion points during peak hours.
- **Relieve capacity constraints:** A smoother travel distribution reduces demand at high congestion points during peak hours. Dorfman (2007) reports that peak pricing can achieve capacity gains between 3% and 10% by moving some users from the peak hour to adjacent periods. As a result, agencies can accommodate more growth in peak ridership and delay the need to build bigger stations, add new rail lines, and purchase more vehicles to expand peak period capacity.
- **Equalize public subsidy:** When the fare closely matches the service cost, the public subsidy is equalized across time periods. The public is more willing to accept a particular fare policy when tax dollars do not appear to favor one time period (or type of customer) over another. In a flat-fare environment, public subsidy is much higher in peak periods.

Lack of Case Study Evidence for Cost Efficiency

Aside from price elasticity figures at KC Metro and Port Authority, the case studies produced very little data on the connection between peak pricing and cost efficiency. Some cases provide a general description of how total ridership was affected by a fare increase. What's missing is how narrowly-defined customer segments respond to the implementation of or change to a time-based fare structure and how shifts in travel behavior affect the financial position of the transit agency. Unfortunately, none of the agencies in this report has conducted an in-depth study of their peak pricing strategy. Further, no agency has detailed records to show how the implementation of a time-based fare structure impacted ridership, revenue, and costs. There are several reasons for this lack of financial analysis:

1. **Lack of quantitative data:** Several agencies use older information technology (IT) systems that do not track time-of-day ridership. Port Authority, SEPTA, and Metro Transit use barrier-free rail systems that rely upon periodic census counts to estimate ridership. No agency stated that they had the technological capability to automatically integrate ridership, revenue, and cost data.
2. **No cost allocation model:** Few U.S. agencies use a robust cost allocation model that accurately measures how costs vary according to factors such as mode, distance, time, direction, and vehicle passenger capacity (Taylor et al., 2000). Most models fail to capture capital costs or properly segregate expenses into variable, semi-fixed, and fixed costs.
3. **Price impact on ridership is unclear:** It is very difficult to isolate the impact of price on ridership. Transit ridership tends to be most influenced by external factors, such as regional economy, fuel prices, population, employment rate, parking prices, and congestion levels. Service frequency and on-time performance influence ridership more than price.[41] Most agencies tend to rely upon unsophisticated price elasticity models that do not reflect how unique customer segments will respond to price. In this report, KC Metro is the only agency to use a robust model to guide fare strategy. However, even this model has not been updated in many years.
4. **Goals not related to cost efficiency:** Some transit agencies utilize peak pricing strategies for reasons not related to cost efficiency. Port Authority implemented peak pricing to encourage riders to switch from cash to prepaid fares to reduce employee theft of cash receivables. SEPTA had historically used peak pricing to shift discretionary trips to off-peak times to leave more room for peak commuters. The case study of D.C. Metrorail was the only one that featured some data linking peak pricing to cost efficiency.
5. **Fare structure evaluation is low priority:** In many cases, peak pricing affects a relatively small percentage of the customer base. On Port Authority, only 1.5% to 2% of total system riders pay peak fares. On SEPTA, roughly 19% of riders using regional rail pay peak fares. Except for D.C. Metro, the peak price differential has shrunk in recent years. In other

[41] Email communication, Dr. Hiroyuki Iseki, University of Toledo, 04/10/08.

words, the percentage difference between the peak fare and the off-peak fare has become smaller over time. Given the above, it is not surprising that agencies have not focused their limited resources on the study of peak pricing.

Transit Agencies Must Know Customers & Costs Before Peak Pricing Study

Despite a lack of case study data on cost efficiency, prior research indicates that transit agencies should seriously consider a time-based fare structure as a way to advance goals related to service effectiveness, social equity, and cost efficiency. Before any study to evaluate the potential of peak pricing, an agency must first possess a deep understanding of their customers and costs. Using customer surveys, focus groups, and other feedback loops, transit authorities can create demand curves for different customer segments. As learned in the case study of Metro Transit, peak riders tend to take transit for different reasons than off-peak riders. This information can feed the development of elasticity models that show how the price-to-ridership relationship varies by travel time, fare media, income, and other factors. A well-developed price elasticity model can help predict how different fare levels will impact total revenue and ridership across customer groups. Second, authorities must migrate from average cost allocation models to those that account for marginal variations in vehicle-passenger capacity, capital costs, and time-of-day costs (Taylor et al., 2000). Using an improved model that reflects true cost data, management will make more informed decisions. Third, transit managers need to understand the consumer value of marginal peak service. During the peak period, higher service frequency lowers wait costs, but in-transit costs may be greater due to longer boarding and alighting times as well as congested roadways and rail right-of-way (Savage and Schupp, 1996). Management must know which effect is stronger and how this relationship varies by time, mode, and route. Despite higher peak fares, a consumer's generalized cost can be lower during the peak if increased peak service lowers wait costs to the point that it off-sets the higher fare and any increase in in-transit costs. When establishing fare levels, transit managers should be aware of the consumer's generalized cost because it will factor into their decision to use the service or not. Finally, agencies need to design key performance indicators that measure progress against stated goals. The goals help to inform what type of peak pricing strategy to implement. The metrics help to evaluate whether the pricing strategy raised or lowered performance.

Shape of Peak Pricing Strategy Depends on Agency Goals

Transit agencies develop fare policies that support organizational goals. These can include:

1. Grow market share for public transit
2. Stimulate "smart growth" land use development
3. Improve air quality: encourage people to switch from cars to transit
4. Reduce congestion on roadways
5. Improve mobility for transit dependents

6. Reduce reliance on public subsidy: increase cost recovery
7. Operate more like a business: align fares with costs
8. Relieve over-crowding on high-demand transit runs
9. Increase efficiency: lower capital and operating expenditures

A peak pricing strategy is better suited to meet some goals rather than others. Based on the earlier list, peak pricing offers greater potential for goals 6 to 9. However, the exact shape of the peak pricing strategy will depend on which of these goals is most important. If cost recovery is the highest priority, transit managers will raise peak fares to the point at which total fare revenue is maximized, regardless of how many customers switch to alternative modes. If capacity relief is the highest priority, management will set the peak price differential and define the peak window to encourage riders to switch to the shoulder of the peak period. However, if customers perceive the peak price differential as relatively small, the off-peak discount may not seem worthwhile. Likewise, a relatively long peak window may discourage riders from moving to the shoulder. For example, if customers would need to board the train before 6:00AM or after 9:30AM to realize the off-peak discount, it may not be worth the disruption to their commuting pattern. Alternatively, transit agencies could adopt a three-tiered strategy, establishing different fare levels for the off-peak, peak, and "peak of the peak", in order to shift the travel distribution. In this structure, customers pay the highest fare for travel during the single busiest hour ("peak of the peak"). A second, lower rate would apply for travel outside that hour but still in the peak period. A still cheaper rate will apply for travel during off-peak periods. This tiered pricing strategy may move people off the busiest hour when they would otherwise never choose to switch to the off-peak. If generating new off-peak ridership is a priority, agencies might consider offering cheaper (or free) transfer rates during the off-peak versus the peak. As learned in the case study of Metro Transit, transfer trips are more common in the off-peak.

Time-Based Fare Structures Should Impact All Customer Segments

Despite the variation within peak pricing strategies, all time-based fare structures should have three common elements. First, they must be expansive enough to impact nearly all riders. Second, future fare increases should have some measure of rationality and predictability. Third, the fare structure must be part of a larger regional transportation policy. As for the first point, transit agencies should follow the lead of KC Metro and develop a peak pricing strategy that covers all payment types, including programs tailored to students, senior citizens, and employer-subsidized plans. All customers should understand that service costs are higher during certain times of the day. The single biggest hindrance to this understanding is the popularity of unlimited ride passes. Economists recognize the power of this marketing tool, but generally favor eliminating it in its current form. Fearnley (2004) argues that the availability of non-restricted, unlimited ride passes gives the market wrong signals. Apart from their own effort in terms of time and inconvenience, pass holders behave as if there is no cost to the extra trip. During the peak period, these pass holders travel on highly discounted fares and pay zero

marginal fare. This generates excessive demand for public transit when costs are particularly high. Fearnley states that agencies can continue to use these passes but should restrict their use to off-peak periods. Alternatively, agencies can focus their customer loyalty programs on fare media, like stored value cards, which deduct per-trip costs. This payment type can feature a customer reward (i.e. 10% bonus for every $20 loaded onto the card) but still deduct a higher fare for peak travel.

Future Fare Increases Should Be Well-Understood and Expected

Transit agencies can raise public acceptance of fare increases when consumers: (1) agree that economic conditions warrant higher fares; (2) believe they have input in the decision-making process; and (3) have time to adjust to the idea of higher fares before they become reality. As described in the literature review, Spock (2007) states that a transit agency may realize several advantages of a "programmed fare increase" that would automatically raise fares every so many years based on certain economic indicators. These advantages include:

- Minimizing agency resources spent on political challenges to fare increases
- Maintaining purchasing power of revenues collected, making it easier to balance the budget
- Eliminating need for larger "catch up" increases that are difficult for consumers to absorb, resulting in lost ridership
- More effectively managing capital programs and maintain service levels because revenue growth is more predictable
- Gaining greater customer acceptance of fare increases that are predictable and well understood
- Staying in compliance with mandated farebox recovery ratios

In four of the five case studies, the peak price differential shrunk over time. In other words, the percentage gap between the peak fare and the off-peak fare became smaller. As a result, customers are less likely to respond to the price differential as intended by those responsible for the fare structure design. When planning for a fare increase, transit managers should seek to maintain a peak price differential that supports the goals of the time-based fare structure.

Time-Based Fare Structures Should Link to a Regional Transportation Policy

The third common element is that all time-based fare structures should be part of a regional transportation policy. For peak pricing to be most effective, regional policies should support congestion pricing on urban freeways. Traditional urban freeways are already under-priced, leading to excessive demand. If transit adopts peak pricing, the customer's demand curve is sufficiently elastic, and few customers have flexibility as to when they can travel, then a significant number of riders could switch from transit to private auto, increasing roadway congestion and pollution. Market inefficiencies increase because transit infrastructure is not fully utilized and highway agencies must build new capacity to accommodate demand for just a few hours each day. As previously discussed, congestion pricing

charges user fees related to the cost of delay that each driver imposes on all other drivers on the highway. By providing a financial incentive for drivers to switch to times, routes, or modes in less demand, congestion pricing encourages drivers to use the existing highway more efficiently. Key benefits include reduced congestion, shorter travel times, more reliable travel times, and more efficient investment. Indirect benefits include reduced fuel consumption and pollution (Congressional Budget Office [CBO], 2009).

Public support for congestion pricing is not strong because many people think it unfair that basic public services, once available to everyone regardless of income, would be allocated on the ability to pay. Critics state that higher-income drivers are more likely to pay the congestion fee and benefit from the faster trip. At the same time, lower-income drivers are worse off because they cancel their trip or switch to a less preferred time, route, or mode. Research confirms that high-income highway users are more likely to use congestion-priced facilities than low-income highway users. However, research has also shown that the decision to use priced lanes is not solely based on income. Studies indicate that roughly one-half of the drivers using such lanes do so only once a week or less (Evans et al., 2003). To address distributional effects, proponents of congestion pricing suggest that a portion of congestion pricing revenues be used to increase transit service levels, especially in areas with a large population of transit dependents (CBO, 2009).

Legislative viewpoints on congestion pricing tend to be highly fractured. Some liberals like the concept because it supports their environmental agenda to encourage smart growth and to reduce pollution. However, other liberals believe that because of social inequities, higher-income taxpayers should make greater contributions to public amenities that are available to everyone. Fiscal conservatives like congestion pricing because of the potential for private investment and the efficiency of market solutions. Federal policy has slowly evolved to support an increase in congestion pricing initiatives. A March 2009 study by the CBO (2009) identified 17 congestion pricing projects in operation across the country; with another 5 under construction, and another 16 under study. However, the divergent viewpoints described earlier make it difficult to secure final approval for implementation. A recent high-profile attempt that failed was led by Michael Bloomberg, Mayor of New York City. He proposed a congestion pricing plan that would charge an $8 fee to anyone entering Manhattan below 86th Street between 6:00AM and 6:00PM. To support the plan, the Bush administration offered a $354 million incentive. A revised version included tax credits for low-income drivers who paid the congestion charge. The governor and state senate supported the plan, but Democrats in the state assembly killed the deal, believing it was a regressive tax on the working class (Hiatt, 2008). Because of the challenges, elected officials will need to invest significant political capital to implement congestion pricing projects.

Whether they realize it or not, Americans pay for space on congested roadways in the form of lost time, polluted air, increased stress, lowered health, and skewed development. Chris Zimmerman, an economist and chair of WMATA's board of directors stated: "If the price of bread were zero, you wouldn't find bread on the shelves. I personally don't believe that roads should be free. We should be subsidizing mass transit, which has all kinds of benefits, as opposed to roads, which have all kinds of costs" (Hiatt, 2008).

Flexible Work Schedules Support Peak Pricing

To support peak pricing strategies, government officials should provide incentives to encourage major regional employers to offer flexible work schedules to their employees. An increasing number of households contain adults who all work outside the home. This generates greater demand for flexible work arrangements so that people can attend to responsibilities outside of the workplace. At the same time, a sharp rise in telecommunication technologies enables employees to conduct work away from the job site. Staggered work schedules can save the government money (reduce the need for costly peak capacity) and save consumers money (easier to take advantage of off-peak discounts). Government can take leadership by adopting expansive policies that encourage flexible work arrangements in their own organizations. In some cities, this could yield significant results. During peak hours, about 50% of D.C.'s Metrorail customers are federal employees.

Time-Based Fare Structures Should Reflect Local Conditions

Not all time-based fare structures are created alike. In fact, researchers argue for variations based on local economics and the political climate. Variations might include:

- Peak pricing only on rail to stimulate migration to less-congested bus service.
- Peak fare discounts for reverse commuters who work in the suburbs where lower parking fees make commuting by car a more attractive alternative.
- Peak fare discounts on under-utilized lines with excess capacity.
- Peak fare discounts at low-traffic stations to divert passengers away from over-crowded stations.

As differentiated fares gain greater public acceptance, Larsen (1998) and Vickrey (1980) envision a time-based fare structure by which fares gradually rise towards the peak before gradually falling again to off-peak levels. Only then will the fare structure effectively reflect marginal costs and reduce the sharp peaks of demand. Transit agencies could display the ever-changing fare price on message boards in plain view of fare gates. The agency website could provide the same information to help consumers make better decisions as to when or whether they choose transit. Of course, the likelihood of this happening in the short term is very low. Consumer awareness of peak pricing strategies is low and many agencies lack the type of cost data needed to calculate the appropriate peak fare at any given time.

Fearnely (2004) proposes a fare structure that charges a lump sum "membership fee" for access to the service in addition to a marginal cost per unit of service. The membership fee is the same whether you make one trip per year or you make several trips per day. In principal, this fee will not alter a passenger's decision as to whether or not to make one extra trip. Therefore, it is efficient pricing in economic terms. The fee should cover the fixed costs of operation. This type of pricing structure is rarely used in public transportation (mostly in European nations) but is the standard in industries such as telecommunications, electricity, water, and sewerage.

The membership fee acts as a constant term in the fare price equation. Every passenger has to pay this in order to access the system. The total price passengers pay for a given period of time (P), is

$$P = F + T*X$$

Where:
F is the constant term, or the membership fee for the period
T is the additional price per trip (equal to marginal cost)
X is the number of trips

This structure features a quantity discount. The more trips a person makes per period, the lower the average fare, P/X. A person who makes only one journey pays F+T per trip. As the number of trips approaches infinity, the average price per trip approaches T. Customers are rewarded for their loyalty through the volume discount.

It is unclear whether this type of fare structure would be successful in the United States. High capital costs and low patronage rates may dictate a membership fee that is too high to attract enough customers. Fearnley does not explain how public subsidy, if used at all, fits into the economic picture.

Time-Based Fare Structures Face Many Challenges
Despite research describing the merits of a time-based fare structure, transit agencies face several challenges to implementing this pricing strategy:

- Uncertainty of the new pricing structure's effects on ridership and revenue.
- Customer disputes with operator when bus delay results in switch from off-peak to peak charges.
- Low consumer awareness of rationale for differentiated fares.
- Risk of fare evasion on barrier-free rail systems; customers board peak trains with off-peak tickets.
- Technology upgrades to accommodate fare structure that changes throughout the day.

Even a strong economic case for peak pricing may clash with political realities. According to Tony Kouneski, Vice President of Member Services for the American Public Transportation Association, “Fare hikes in the transit industry are not done by transit management on a strategic level such as the way you would plan for development of other aspects of your operations … What is important is that it is as much a political process as a management process. It takes time, good planning effort and effective communications to be successful” (Gardner, 2005). Transit agencies must work closely with elected officials to build a coalition of influential interest groups that support peak pricing. In September 2007, the New York Metropolitan Transportation Authority proposed a time-based fare structure. Peak periods were defined as 6:00AM-10:00AM and 3:00PM-7:00PM. Peak riders using cash would be the only customers to pay the peak fare. All other riders would receive some kind of discount. At the time, roughly 14% of the 7.2M weekday riders paid the full fare. Agency officials predicted that 5% to 10% of peak riders would switch to off-peak hours. Others would use pre-paid media to avoid the peak charges, dropping the portion of full-fare riders from 14% to 8% (Olshan, 2007). Responding to critics, proponents explained that low-income customers do not typically pay the full fare -- only those who rarely use the system and don’t understand the discounts. Local newspaper articles didn’t explain why, but by December 2007, the agency withdrew the pricing plan from further debate (Egbert and Donohue, 2007).

To be clear, peak pricing will not solve the current budget woes plaguing many transit agencies across the country. KC Metro, which has one of the most expansive time-based fare structures, faced a $70 million budget gap for fiscal year 2009 (Seattle Post-Intelligencer Editorial Board, 2008). Some of this gap was driven by a $45 million drop in sales tax revenue. However, a significant portion was the result of growing labor costs. The Seattle business community authored a recent report, stating that between 2000 and 2007, total operating costs for KC Metro’s bus service increased by 42% compared to an 8% increase in service hours. The report stressed that rising labor costs “must not be used to justify continuing high rates of cost growth. The closer total cost growth can be held to annual inflation rates, the more likely that resources can be directed into improving service quality and adding service to meet ridership demand” (Municipal League Foundation, 2008). While peak pricing holds promise for efficiency gains, it should be viewed as only one weapon in the battle to improve the productivity and sustainability of mass transit systems across the country.

CONCLUSION

This report summarizes a significant body of academic research that indicates peak pricing can enhance service effectiveness, improve social equity across riders, and increase cost efficiency. The author studied five major U.S. transit systems that use such a pricing structure and found that results were largely consistent with past academic studies. One significant outcome is that because flat fares don't address cost variability by time, distance, or mode, they may hurt the financial position of the transit organization. In a flat-fare environment, relatively expensive trips (peak, long-distance, rail) are used much more often than if they were priced according to the cost of the service. Conversely, relatively cheap trips (off-peak, short-distance, bus) are over-priced, and therefore used much less often than if the price was based on service cost. As a result, transit agencies must supply a greater number of under-priced trips, and lose ridership and revenue from over-priced trips. Because of this inefficiency, the agency must raise the fare level, creating the heaviest burden on low-income riders who are more likely to take cheap trips (off-peak, short-distance, bus) and who can't afford to purchase deeply discounted fare options like monthly passes.

When at capacity, transit agencies can't easily add a few more trains or personnel. Instead, they spend large sums to renovate stations, build new right-of-way, and expand the network. Proponents of peak pricing argue that it isn't fair to ask all passengers to pay for the expense of new capacity to handle downtown commuters for a few hours each day. Rather, those who benefit from the new capacity should largely pay for these expenditures. Likewise, why should a consumer who uses local bus service in off-peak hours over-pay so that rush hour commuters can benefit from enhanced service without paying any more for it? The author understands that a flat-fare structure can be easier to explain than a time-based fare structure. However, he believes that this report clearly demonstrates why a flat-fare structure is anything but fair.

LIST OF REFERENCES

American Public Transportation Association. (2003). *Glossary*. Retrieved November 2, 2006, from http://www.apta.com/services/safety/glossary.cfm

Bly, P. H. (1976). *The effect of fares on bus patronage.* Transport and Road Research Laboratory Report No. 733. London: Transportation Research Laboratory.

Brewer, J. (2008, February 9). In 2007, bus and light-rail ridership jumps 5 percent. *St. Paul Pioneer Press*, p. B5.

Byrne, P. (1998, December 2). Rewarding failure. *SF Weekly*. Retrieved February 20, 2009, from http://www.sfweekly.com/1998-12-02/news/rewarding-failure/

Cabanatuan, M. (2005, December 31). BART, Caltrain greet 2006 by increasing riders' fares – Commuters unhappy that cost public transit going up again. *The San Francisco Chronicle,* p. B1.

Cervero, R. (1981). Efficiency and equity impacts of current transit fare policies. *Transportation Research Record, 799*, 7-15.

Cervero, R. & Wachs, M. (1982). An answer to the transit crisis: The case for distance-based fares. *Journal of Contemporary Studies, 5*(2), 59-70.

Clements, H., (1997). A new way to predict transit demand. *Mass Transit, 23*(4), pp. 49-52.

Congressional Budget Office. (2009). *Using pricing to reduce traffic congestion*. Retrieved April 3, 2009, from http://www.cbo.gov/doc.cfm?index=9750

Curtin, J.F. (1968). Effect of fares on transit riding. *Highway Research Record, 213,* 8-18.

Dorfman, M. (2007). *Future contactless payment options for transport for London: Demand, cost, equity, and fare policy implications*. Unpublished master's theses, Massachusetts Institute of Technology, Boston.

Egbert, B. Donohue, P. (2007, December 10). How we'll fare. *The New York Daily News*, p. 4.

Evans, G. W. (1994). Working on the hot seat: Urban bus operators. *Accident Analysis and Prevention*, *26*(2), 181-193.

Evans, J.E. (2004). Transit scheduling and frequency. In Transit Cooperative Research Program (Ed.), *Traveler response to transportation system changes*. Washington D.C.: Transportation Research Board.

Evans, J.E., Bhatt, K. & Turnbull, K. (2003). Road value pricing. In Transit Cooperative Research Program (Ed.), *Traveler response to transportation system changes*. Washington D.C.: Transportation Research Board.

Fairhurst, M. H., and Morris, P. J. (1975). *Variations in the demand for bus and rail travel up to 1974*. (Report R210). London, England: London Transport Executive.

Fearnley, N. (2004). *Inventive pricing of urban public transport*. Retrieved November 4, 2006, from www.aetransport.org/lc_files/files/LPT-H-03%20Fearnley.pdf

Federal Highway Administration. (2006). 2006 status of the Nation's highways, bridges and transit: Conditions and performance. Retrieved April 3, 2009, from http://www.fhwa.dot.gov/policy/2006cpr/index.htm

Federal Transit Administration. (2005). *National Transit Database, 2005* [Data file]. Available from National Transit Database, http://www.ntdprogram.gov/ntdprogram/data.htm

Federal Transit Administration. (2007). *National Transit Database, 2007* [Data file]. Available from National Transit Database, http://www.ntdprogram.gov/ntdprogram/data.htm

Fielding, G. J. (1995). Congestion pricing and the future of transit. *Journal of Transport Geography, 3*(4), 239-246.

Gardner, M. (2005). Managing your money: Putting a "price" on fare change. *Mass Transit, 31*(1), 24-28.

Geringer, D. (2007, July 31). Seniors get break on transit. *Philadelphia Daily News*, p. 04.

Geringer, D. (2008, February 27). SEPTA ridership up, despite fare increases. *Philadelphia Daily News*, p. 09.

Gillen, D. (1994). Peak pricing strategies in transportation, utilities, and telecommunications: Lessons for road pricing. In Transportation Research Board (Ed.), *Curbing gridlock: Peak-period fees to relieve traffic congestion. Vol. 2: Commissioned papers* (pp. 115-151). Washington D.C.: National Academy Press.

Grata, J. (2008, March 13). Port authority ridership up as gasoline prices increase. *Pittsburgh Post-Gazette*, p. B-8.

Grayling, T. & Glaister, S. (2000). *A New fares contract for London*. London, England: Institute for Public Policy Research.

Hague Consulting Group. (1999). *Costs Of private road travel and their effects on demand, including short and long term elasticities* (Contract No: RO-97-SC.2035). Den Hague, Netherlands: European Commission, Directorate-General for Transport.

Harlow, T. & McAuliffe, B. (2008, May 10). Buses and trains have to pay the fuel bills too. *Star Tribune*, p. 1B.

Hensher, D.A. (1997, June). *Establishing a fare elasticity regime for urban passenger transport: Non-concession commuters* (Working Paper, ITS-WP-97-6). Sydney: Institute of Transport Studies, University of Sydney.

Hiatt, F. (2008, April 14). The bumpy road to congestion relief. *The Washington Post,* p. A15.

Kain, J. F. & Liu, Z. (1999). Secrets of success. *Transportation Research A, 33*(7/8), 601-624.

King, L. (2007, July 8). SEPTA 's week of highs - and lows - When fare hikes take effect tomorrow, officials predict a drop in ridership. *Philadelphia Inquirer,* p. B01.

Lago, A.M., Mayworm, P.D. & McEnroe, J.N. (1992). Transit ridership responsiveness to fare changes. *Traffic Quarterly, 35*(1), 117-142.

Lange, L. (2008a, August 12). Fall transit proposal has too few buses, critics say – But backers insist new light rail will free up more service. *Seattle Post-Intelligencer*, p. A1.

Lange, L. (2008b, November 18). Bus fares rising 50 cents – Council has plans to cut expenses, too. *Seattle Post-Intelligencer*, p. B1.

Lange, L. (2008c, November 25). Metro urged to tighten its belt – Report demands more transparency. *Seattle Post-Intelligencer*, p. B1.

Larsen, O.I. (1998) *Elements in an Optimum Transport Policy* (ISBN 82-480-0067-2). Oslo, Norway: The Institute of Transport Economics.

Lee, S., Lee, Y. H., & Park, J.H. (2003). Estimating price and service elasticity of urban transportation demand with stated preference technique: Case of Korea. *Transportation Research Record: Journal of the Transportation Research Board*, *1839*, 167-172.

Lindblom, M. (2008a, June 4). Metro fare increase ahead? - Agency seeks ways to cover fuel gap county leaders vow not to cut bus service. *The Seattle Times*, p. B1.

Lindblom, M. (2008b, September 7). Region's buses overflow, squeezing riders, system - High fuel prices boost usage, but are busting transit budgets. *The Seattle Times*, p. A1.

Litman, T. (2006). *Transportation elasticities: How prices and other factors affect travel behavior*. Victoria, British Columbia: Victoria Transport Policy Institute.

Luhrsen, K. F. & Taylor, B.D. (1997, August). *The high cost of flat fares: An examination of ridership demographics and fare policy at the Los Angeles MTA* (Working Paper). Los Angeles, California: UCLA Institute of Transportation Studies.

Mansfield, E. & Yohe, G. (Eds.). (2004). *Microeconomics* (11th ed.). New York: W.W. Norton & Company, Inc.

Mayworm P.D., Lago, A.M. & McEnroe, J.N. (1980). *Patronage impacts of changes in transit fares and services*. Bethseda, MD: Ecosometrics Incorporated.

Pratt, R.H. (1999). Transit pricing and fares. In Transit Cooperative Research Program (Ed.), *Traveler response to transportation system changes*. Washington D.C.: Transportation Research Board.

Metropolitan Council. (2007a). *2008 unified operating budget*. Retrieved January 15, 2009, from http://www.metrocouncil.org/about/2008Budget/AdoptedBudget.pdf

Metropolitan Council. (2007b). *Program evaluation and audit, Hiawatha light rail: Ridership reporting and fare compliance*. Retrieved October 10, 2007, from http://councilmeetings.metc.state.mn.us/audit/2007/documents/2007-A09.pdf

Metro Transit. (2006). [Customer survey]. Unpublished raw data.

Metro Transit. (2008). [Bus ridership excluding transfers]. Unpublished raw data.

Municipal League Foundation. (2008, November). *Review of Metro transit, November 2008*. Retrieved December 8, 2008 from http://www.munileague.org/about-us/press-releases/Metro%20Report.pdf

Nelson, E.N. (2006, September 25). A flat fare for BART just wouldn't be fair. *San Mateo County Times*, p. A15. Retrieved November 3, 2007 from http://groups.yahoo.com/group/BATN/message/32278

Northwest Research Group. (2007). *King County Metro 2006 Metro rider / non-rider survey final report.* (Available from King County Metro from King Street Center, 201 S. Jackson St., Seattle, WA 98104)

Nussbaum, P. (2007, April 27). Rail ridership up, SEPTA adds cars. *The Philadelphia Inquirer*, p. B07.

Olshan, J. (2007, September 27). Most riders will give no quarter to MTA. *The New York Post*, p. 2.

Oram, R. L. (1990). Deep discount fares: Building transit productivity with innovative pricing. *Transportation Quarterly, 44*, 419-440.

Orange County Transportation Authority. (2006). *Annual financial report: 91 express lanes fund*. Retrieved April 4, 2009, from http://www.octa.net/uploadedfiles/Files/pdf/0691annual.pdf

Parry, I.W. & Small, K.A. (2005, August). On the optimal fares for public transport. In *Successes and failures of traffic demand management*. Conference conducted at Napier University, Edinburgh, Scotland.

Pearlstein, S. (2006, December 29). The last captive market: Commuters. *The Washington Post,* p. D1.

Pham, L. & Linsalata, J. (1991). Effects of fare changes on bus ridership. Washington D.C.: American Public Transportation Association.

Pratt. (2000, March). *Traveler response to transportation system changes, interim handbook* (TCRP Web Document 12). Garrett Park, Maryland: Transit Cooperative Research Program.

Puget Sound Regional Council & Washington State Department of Transportation. (2007). *PSRC 2006 household activity survey analysis report*. Retrieved April 10, 2008, from http://psrc.org/data/surveys/hhsurvey/index.htm

Roberts, G. (2008, March 31). Buses are fuller – and later. Rising gas prices send commuters to metro, affecting on-time service. *Seattle Post-Intelligencer*, p. B1.

Saltzman, A. (1992). Public transportation in the 20th century. In G. E. Gray and L. A. Hoel (Eds.), *Public transportation*, (2nd ed., pp. 24-25). Englewood Cliffs, N.J.: Prentice Hall.

San Francisco Bay Area Rapid Transit District. (2008). *Fiscal year 2009 budget*. Retrieved October 2, 2008, from http://www.bart.gov/docs/FY09_Budget.pdf

Savage, I, (1997). Scale economies in United States rail transit systems. *Transportation Research A, 31*(6), 459-473.

Savage, I. (1999). *Can privatization solve all of Chicago's public transportation problems?* Retrieved November 4, 2008, from Northwestern University, Department of Economics and the Transportation Center Web site: http://faculty.wcas.northwestern.edu/~ipsavage/605-manuscript.pdf

Savage, I. (2004). Management objectives and the causes of mass transit deficits. *Transportation Research A, 38*(3), 181-199.

Savage, I. & Schupp, A. (1996). Evaluating transit subsidies in Chicago (Working Paper). Retrieved December 7, 2008, from Northwestern University, Department of Economics Web site: http://74.125.95.132/search?q=cache:ttIdBx8LpfQJ:faculty.wcas.northwestern.edu/~ipsavage/422-manuscript.pdf+evaluating+transit+subsidies+in+chicago&cd=2&hl=en&ct=clnk&gl=us

Seattle Post-Intelligencer Editorial Board (2008, August 5). Metro fares: Catching the bus? [Editorial]. *Seattle Post Intelligencer*, p. B4.

Seddon, P.A., & Day, M. P. (1974). Bus passenger waiting times in greater Manchester. *Traffic Engineering and Control, 15*(9), 442-445.

Small, K., Winston, C., & Yan, J. (2006). Differentiated road pricing, express lanes and carpools: Exploiting heterogeneous preferences in policy design. In Burtless, G. & Pack, J.R. (Eds.), *Brookings – Wharton papers on urban affairs: 2006*. Washington D.C.: Brookings Institution Press.

Southeastern Pennsylvania Transportation Authority. (2007a). *Fiscal year 2007 operating budget and fiscal years 2008 to 2012 financial projections.* Retrieved September 29, 2007, from http://septa.org/inside/reports.html

Southeastern Pennsylvania Transportation Authority. (2007b). *SEPTA regional rail ridership census* [Data file]. Available from Southeastern Pennsylvania Transportation Authority, 1234 Market Street, 4th Floor, Philadelphia, PA 19107.

Southwestern Pennsylvania Commission. (2008). [Transit rider survey 2007]. Unpublished raw data. (Available from Southwestern Pennsylvania Commission, 425 Sixth Avenue, Suite 2500, Pittsburgh, PA 15219)

Spock, L.M. (2007). *Fare policy regarding regular and/or inflation-related ("programmed") price increases*. Retrieved December 29, 2008, from NYU Wagner Rudin Center for Transportation Policy & Management Web site: http://wagner.nyu.edu/rudincenter/farepolicy.pdf

Streeting, M. & Charles, P. (2006, September). *Developments in transit fare policy reform*. Retrieved March 5, 2007, from The University of Queensland, Australia Web site: http://espace.library.uq.edu.au/view/UQ:7732

Sun, L.H. (2006, December 11). Metro considers increasing rail fares: Service cuts are also among ideas to plug $116 million shortfall. *The Washington Post*, p. A01.

Sun, L.H. (2007a, March 30). Metro drops plan for fare increases. *The Washington Post*, p. A01.

Sun, L.H. (2007b, November 7). D.C. leads ridership surge – Biggest increase is found in city. *The Washington Post*, p. B3.

Sun, L.H. (2007c, November 18). Riders give Metro an earful – Board will weigh gripes in finalizing fare increases. *The Washington Post*, p. C1.

Sun, L.H. (2007d, December 12). Amid complaints, Metro reverses cuts – 6-car trains will be back in off hours. *The Washington Post*, p. B3.

Sun, L.H. (2007e, December 12). Metro passes largest fare hikes in its history. *The Washington Post*, p. A1.

Sun, L.H. (2008a, January 10). Metrorail reports 17-month slide in on-time service. *The Washington Post*, p. A01.

Sun, L.H. (2008b, May 6). Metro won't raise fee to park with more riders, agency's financial squeeze has eased. *The Washington Post*, p. B01.

Taylor, B.D., Garret, M. & Iseki, H., (2000). Measuring cost variability in provision of transit service. *Transportation Research Record: Journal of the Transportation Research Record, 1735,* 101-112.

The Seattle Times Editorial Board. (2007, November 20). It might be time to lower bus fares [Editorial]. *The Seattle Times*, p. B8.

Transit Cooperative Research Program. (1996). *Fair policies, structures, and technologies.* Retrieved October 10, 2006, from gulliver.trb.org/publications/tcrp/tcrp_rpt_10-d.pdf

Transit Cooperative Research Program. (1999). *Practices in assuring employee availability* (Synthesis 33). Washington D.C.: Transportation Research Board.

Transit Cooperative Research Program. (2004). *Traveler response to transportation system changes*. Washington D.C.: Transportation Research Board.

Transport for London. (2003). *Central London congestion charging: Impacts monitoring, first annual report*. London: Author.

Transportation Research Board. (1994). *Curbing gridlock: Peak-period fees to relieve traffic congestion.* Washington D.C.: National Academy Press.

Transportation Research Laboratory. (2004). *The Demand for Public Transit: A Practical Guide* (Report No. 593). Retrieved March 2, 2007, from www.demandforpublictransport.co.uk

United States Census Bureau. (2005-2007). *United States census 2000*. Retrieved October 13, 2008, from http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=Search&geo_id=&_geoContext=&_street=&_county=minneapolis&_cityTown=minneapolis&_state=&_zip=&_lang=en&_sse=on&pctxt=fph&pgsl=010

Upholt, B. (2008, September 10). 'An absolute boon' for transit riders - SEPTA begins three service expansions on the R5 Paoli-Thorndale line. *Main Line Life,* pp. 1, 13.

Vickrey, W. (1980). Optimal transit subsidy policy. *Transportation, 9*(4), 389-409.

Washington Metropolitan Area Transit Authority. (2001, December). *Metro core capacity study.* Retrieved February 8, 2009, from www.wmata.com/pdfs/planning/CoreCapacity_ExecSum.pdf

Washington Metropolitan Area Transit Authority. (2006, November). *Metrorail revenue vehicle fleet management plan*. Retrieved January 8, 2009, from http://www.wmata.com/pdfs/planning/Rail_Fleet_Management_Plan_Revised_20070601.pdf

Washington Metropolitan Area Transit Authority. (2008). *Approved fiscal 2009 annual budget* (Administrative Item #2 03-27-08). Washington D.C.: Author.

Webster, F.V., Bly, P.H. & Paulley, N.J. (1988). *Urban land-use and transportation interaction: Policies and models*. Brookfield, Massachusetts: Avebury.

Wilson, N. (2006). [Lecture 17, transit labor]. Retrieved March 20, 2009, from Massachusetts Institute of Technology, Department of Civil and Environmental Engineering Web site: http://ocw.mit.edu/NR/rdonlyres/Civil-and-Environmental-Engineering/1-259JFall-2006/6B2D9579-3D0B-4CBB-B895-19F1300AD38C/0/lect17.pdf

Yankelovich, D. (1994). *How changes in the economy are reshaping American values*. Retrieved January 8, 2007, from http://www.danyankelovich.com/howchangesineconomy.pdf

APPENDIX

Appendix 1

Request for Information

1. Do you have any studies or reports related to trip purpose by time of day? I'm interested in learning as much as I can about the share of discretionary vs. non-discretionary trips and how those percentages vary by different times of day and night. It would also be very helpful if your studies include data that is broken down by different categories like socioeconomic status, gender, or race. Finally, does the trip data include distance covered? For example, do discretionary trips tend to cover shorter distances than non-discretionary trips? How does the average peak period distance compare to the average off-peak distance?

2. I'm interested in reviewing some of the raw ridership data. Specifically, I'm interested in learning how travel patterns vary by time of day across different types of fare media. What is the best method to view this data? Can you provide this information in Microsoft Excel format? I have a separate document that details the type of data sets that would be most valuable to me. (Below is what was detailed in the separate document):

   A. Data Set #1
   1.Time: 1997-2006 (by year)
   2.Mode: Total Rail vs. Total Bus (reported separately)
   3.Facts: # first rides; # second rides; # third or more rides; gross dollars (by ride)
   4.Market: by each fare category (cash, stored value card, reduced fare card, etc.)

   Note: For example, data set #1 would allow a drill-down to show # first rides in 2004 by total bus for those customers paying cash only.

   B. Data Set #2
   1.Time: Most recent week (by day by hour) vs. the prior year week (by day by hour)
   2.Mode: Total Rail vs. Total Bus
   3.Facts: # first rides; # second rides; # third or more rides; gross dollars (by ride)
   4.Market: by each fare category (cash, stored value card, reduced fare card, etc.)

Note: Data Set #2 would allow me to understand how ridership patterns vary by hour for each day of the week (including Saturday and Sunday). There is also a comparison of the data to the prior year. For example, looking at specific days/hours during the week ending 3/17/07 and comparing it against week ending 3/18/06. The ideal week would reflect average ridership patterns and doesn't coincide with a holiday or major civic/sporting event that might skew data.

C. Data Set #3

This request is related to data that would show the relative impact of a time-based fare structure on ridership patterns. Specifically, I'm interested in collecting data pre-implementation vs. post-implementation. The type of data would be very similar to Data Set #2 – so long as the first part of the data reflected a flat-fare structure (pre-implementation) compared to the time-based fare structure (post-implementation). In other words, how did ridership patterns change when the transit agency shifted from a non-time-based fare structure to a time-based fare structure.

3. Do you have any studies on the typical rail vs. bus customer and how that compares to all residents in the region? I'm interested in learning about what percentage of households own a car and how many cars they own. Also, what percentage of transit riders are "choice riders" (own a car) vs. "transit dependents" (don't own a car) and how those percentages compare across different demographic segments related to age, socioeconomic status, gender, etc?

4. Do you have any elasticity studies for your transit system? I'm interested in any price elasticities of demand and income elasticities of demand studies you might have. Also, do you have any studies that show cross elasticities of demand? For example, if the transit fare increases (especially during the peak period), what percent of customers will choose to take another mode (walk, bike, car) or choose to travel at an off-peak time? Further, do any of these studies calculate values by different segments of your customer base? For example, how does the price elasticity of demand vary by age group, race, gender, socioeconomic status, type of fare media used, time of day, etc? For example, this data might show that higher income groups are less price sensitive to fare increases, willing to absorb the higher fare to continue taking transit.

5. Do you have any reports, studies, or audits on transfer trips? I'm interested to know how the number of transfer trips varies by time of day. For example, do peak period trips (during the rush hour) tend to include more transfers?

Appendix 2

Time-Based Documents Collected from Transit Agencies								
Transit Agency	Budget Document	Rider Profile	Ridership Data	Elasticity Studies	Fare Media Usage	Trip Length	Policy Rationale	Revenue Impact
D.C.	X	X	X		X	X		
Philadelphia	X		X					
Seattle	X	X		X				
Mpls/St. Paul	X	X	X		X			
Pittsburgh	X	X					X	

Appendix 3

Transit Agency	*Key Contacts*
Washington D.C.	**Washington Metropolitan Area Transit Authority:** Kristin Haldeman
Philadelphia	**Southeastern Pennsylvania Transportation Authority:** Dan Casey, Michael Seonia, Ken Miller, Bharatt Gohel
Seattle	**King County Metro Transit:** Mike Wold, Chuck Sawyer, Greg Lipton, Anita Barreca, Raj Cheriel; **Puget Sound Regional Council:** Mark Charnews, Neil Kilgren
Mpls/St.Paul	**Metro Transit:** Lynn Wallace, Bruce Howard, Rich Moore
Pittsburgh	**Port Authority of Allegheny County**: Dante Calderone, Darcy Cleaver, David Wohlwill; **Southwestern Pennsylvania Commission (MPO)**: Carol Uminski, Chuck Imbrogno