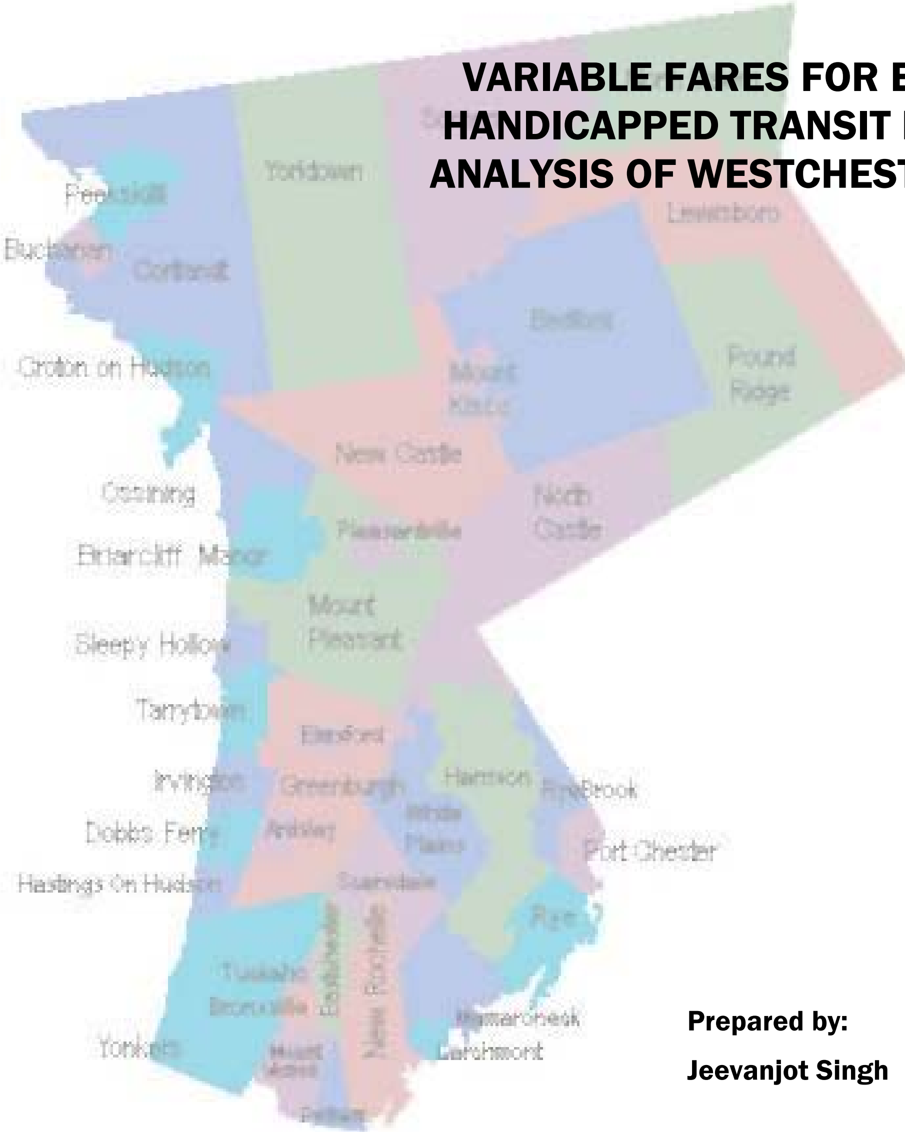
VARIABLE FARES FOR ELDERLY & HANDICAPPED TRANSIT RIDERS: AN ANALYSIS OF WESTCHESTER COUNTY



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Sept. 11th Memorial Program for Regional Transportation Planning

September 11th Memorial Program
NYMTC
For Regional Transportation Planning

IN MEMORY OF
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1. Introduction

With the baby boomer population inching closer to their retirement age, their mobility and transportation needs have taken precedence in planning departments around the country.

APTA and other public transportation agencies are gearing up to address the forecasted transit demand for the increasing elderly population.

Westchester County Department of Transportation is implementing many key programs in order to make its Bee-Line Bus Transit System more senior friendly. Towards achieving the goals of providing comfortable, affordable and safe rides for its elderly and handicapped (E&H) population, the department has expressed interest in exploring alternatives with variable fare options for peak and off-peak periods.

This study hopes to evaluate these alternatives, with a benefit/cost analysis, in order to recommend the most attractive option in terms of fare box returns and/or ridership gains.

The elderly and handicapped commuter group accounts for 6-10% of the total ridership on the system. These numbers have been calculated from archived monthly ridership data from 1997 to 2005. This share is predicted to increase with the baby boomer population becoming of age, as well as in response to the numerous programs that Westchester County officials have initiated to attract more seniors to the system.

From an overview of the previous studies it was found that a fare elasticity study endeavor was undertaken in early 1970s, by Ecosometrics, Inc., wherein the fare elasticity for Westchester County, calculated by using the non-experimental time-series data and least square regression of time series data by Hartgen et al., was -0.57. This is atypical of the bus transit systems where ridership is primarily thought of as being captive.

This study aims to analyze and develop:

1. Fare Elasticity for Bee-Line Bus transit system today
2. Fare Elasticity for E&H commuter group
3. Peak and off-peak period loads of E&H commuters on the system
4. Variable peak and off-peak fare alternatives for E&H group
5. Benefit/ Cost for the alternatives

During discussions with the DOT officials, the following constraints were outlined:

1. The peak period fares will not exceed the full adult fares
2. Three off-peak E&H fare options will be analyzed
    a. $0.50
    b. $0.25
    c. Free fare

3. A comparative study will be done to understand other bus transit systems' view of variable fare policy, their successes and failures.

4. The variable fare alternatives will be analyzed using a cost benefit analysis constrained by the assumptions formulated and mentioned.

5. The recommended alternative will not reduce the fare box revenues by more than 5% provided there are ridership gains

6. The ridership loses to the system will not exceed 5% provided the system gains revenue.

This study, undertaken in partial fulfillment of the September 11th Memorial Fellowship awarded by NYMTC in collaboration with UTRC, aims to accomplish the listed goals and build a precedence for similar bus transit studies in the future.

2. Westchester County: Background and History

2.1. History[1]

Westchester County was a flourishing dairy farming community till the age of dams and reservoirs in 1860s'continuing through the 1920s. In 1900s' as the population of New York increased, the influx of citizens to the suburbs began in earnest. The towns and villages became incorporated, began collecting taxes and revenue in order to provide the civil amenities and public services. The horse driven trolley was introduced in Westchester County towns in 1880s', and electrified by 1890s'. Diary farming was almost obliterated in Westchester following the Great Depression. In 1964 there were 18,500 acres of farm land in Westchester; by 1974 only 9000 acres remained.

The Parkways came to Westchester with the building of the Bronx River Parkway, followed by the Saw Mill River, Hutchinson River, Taconic and Cross County Parkways.

Transportation was developed; roads were paved to accommodate the growing population. Paved roads led way for traffic regulations and traffic lights. The old trolleys were replaced by buses. The Toonerville Trolley of Pelham made its last run in 1937, with the Westchester Bus System replacing it.

2.2. Bee-Line History:[2]

In 1970, after securing the State legislation vesting all transit franchising powers with the County government, the Westchester County Department of Transit was established. The Department of Transit, with one Commissioner, Secretary and 3 support staff, acquired 17 private operators in 1972. By 1974, with passing of Local laws, the Department of Transit was renamed Department of Transportation to reflect broader responsibilities. Transit became a joint venture between the DOT (administrative responsibilities) and private contractors (operational responsibilities) and contracts were negotiated with 11 of the 17 private operators at the time, with 93% of the riders services included in the BOA (Bus Operating Assistance) program. The Blue Ribbon Panel was formed to look into the financial aspects of Transit. They concluded that the increasing deficit could be contained by providing only the amount of service that is required and periodically increasing the fares. This conclusion provided the basis of unifying the system, giving the County control over buses, routes, fares and services in exchange for subsidies passed to the private operators.

On May 1, 1978 the system was consolidated with simplification of fare structure, removal of any inequities in the system.

Between 1980 and 1982 many other changes in the public/private partnership were made, with remarkable acclaim and recognition by the Federal Transit Administration.

The years following made it apparent that the system had an identity problem and people were unsure of 'who' was providing the transit in Westchester County. On May 19, 1987 the system was officially named "The Bee-Line Transit" with a friendly 'bee-in-flight' symbol.

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[1] http://www.westchestergov.com/history/

[2] 2004 Annual Report for the Bee-Line Transit System, May 31, 2005

By 1990 the County retired the last of the privately owned buses. In 1994 the County built its first County-owned bus facility in Valhalla (Cerrato) housing over 100 vehicles. The 1998 purchase of the CMF (Central Maintenance Facility) saved $2.5 million in rental costs, providing the County with complete ownership assets and administrative control over the Bee-Line System.

2.3. Present

The Bee Line System currently operates 36 local routes, 16 of them are handicapped accessible. There are 3 summer service routes, 9 bus-to-rail commuter routes – 6 of them being handicapped accessible. The County DOT also operates 9 Express routes, 2 of which are handicapped accessible. There are 9 shuttle service routes in addition to the above mentioned routes. There are a total of 67 routes with 347 vehicles in service.[3]

The following is the 2005 route map of the Bee-Line Transit System (Figure 1), listing the routes and the ones that are accessible to the handicapped.[4]

The Department of Transportation regularly oversees the following:

- Service standard, routes schedules
- Contract operations of surface transit workers
- Capital equipment and support services to the System
- Outreach and information dissemination throughout the county
- Financial and Administrative support
- Management Information system
- Planning and implementing transportation services at regional and local level
- Access to non-County funding grants and programs
- Intermodal coordination to encourage economic development, limit energy consumption and reduce air pollution.[3]

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[3] 2004 Annual Report for the Bee-Line Transit System, May 31,2005

[4] http://beelinebus.westchestergov.com/images/Transit%20Guide%20Map%202005.pdf

Figure 1: Bee-Line System Route Information

Lately, the County officials have been interested in coming up with programs that will benefit the elderly population in the County, both in terms of providing mobility and accessibility as well as a comfortable ride.

There have been a number of community outreach programs.

This was the reason behind Westchester County Officials to support this study which, in partial fulfillment of the Fellowship Award instituted by NYMTC (New York Metropolitan Transportation Council), looks into the fare elasticity and ridership models in order to come up with off-peak fare discounts for E&H group of commuters.

Transit, as all transportation systems are, is a service offered to the community. The service that is not used is a lost resource. Peak period usually witnesses standing loads on most routes in response to work related travel that is inelastic. Most of the peak period commuters are bound by time. Discretionary commuters traveling during peak periods look at uncomfortable and uneasy ride conditions.

Shifting this group of commuters to the off-peak periods will not only help provide a better LOS (level of service) during the peak periods, it will also help with the utilization of transit service during the time that the system runs empty. This will optimize the system operation, help maintain a higher LOS, meet schedule times and provide a comfortable ride to the E&H commuter.

3. Scope of the Study

The scope of the study dwells in reviewing comparables within the United States Bus Transit Systems database. The review was restricted to the properties that offer, or at some point offered, time-of-day pricing/ variable pricing/ time-of-day discounts.

Section 5 lists all these transit properties studied with a view to coming up with a reasonable comparative to the Westchester County Bee-Line System.

Further, the scope is also inclusive of price elasticity analysis of the system's E&H commuter group to get a grip on the elasticity and flexibility of their trips. The elasticity model looks into the Arc Elasticity of the system, with all its various fare structure riders. The sensitivity analysis on the elasticity values gives an idea on the realistic nature of the values. The elasticity model is developed for both peak and off-peak periods for better understanding the temporal differences.

Section 6 describes the model formulation, calibration and validation with the elasticity values that are best suited to the system and to E&H commuters specifically.

The model gives an idea of how the fare structure changes will affect the ridership numbers and fare box revenues. As we are holding all the other fare structures as constant, and experimenting with E&H fares only, the ridership changes will be to the E&H commuter group only. The four fare alternatives included in the analysis of the model are as follows:

Table 1: Study Scenarios

SCENARIO	BASE FARE	OFF-PEAK FARE
No change Alternative	E&H discounted fare	E&H discounted fare
Alternative 1	E&H discounted fare	$ 0.50
Alternative 2	E&H discounted fare	$ 0.25
Alternative 3	E&H discounted fare	Free

The benefit analysis of all these alternatives is done with the assumption that there is no extra cost incurred in adopting one or the other alternative on the list.

Section 7 describes the benefits of each of the alternatives in descriptive as well as tabular format.

Section 8 provides the conclusions from the study and lists some recommendations.

A bibliography of the literature that was studied during the project and went towards the preparation of this report is published as the concluding section of the report.

4. Transit Pricing: A Literature Review

4.1 Introduction

Transit has been innovative in its pricing strategy in the early 20th century, when rails and buses were a primary means of transportation for the working class, as well as the rich. Around the time when the automobile revolution was in its infancy, and the trains carried most intercity traffic whereas intracity buses were often the preferred means, peak hour ridership on various transit modes constituted similar conditions that we experience on roads now. Congestion mitigation (in terms of riders on the mode) and spreading the peak in order to optimize the utilization of the facility, in addition to revenue concerns, were paramount factors in fare structuring, necessitating the research into and consequent practice of innovative price strategies. These strategies were primarily justified by economies of cost utility, marginal and average, and further impressed upon by utility companies pricing schemes. As with the telephone and electric companies, where they charge higher prices for peak hour consumption and lower their levies during off-peak hours, railroad and bus companies, having a comparative increasing returns to scale, adapted a similar price structure where they charged higher adult fares during peak usage period and lowered the same when the rider numbers dropped. The work on transit elasticities and cross-elasticities was also done in the 1980's with emphasis on short-run and medium-run elasticities at a time when the incomes were lower and the population more transit dependent than today. These elasticities need to be reconsidered and re-evaluated in order to be applicable to the situation in more recent times. (Todd Litman)

4.2 Literature Review

Transit fare structure has been reflecting the time of day pricing since the early seventies, as reported by a paper, "Evidence on time-of-day pricing in the United States, Volume 2, Appendices and Case Studies" by Robert Cervero with research assistance from Mark Hansen, Therese Watkins and Joel Markowitz, in May 1984. The paper studied 32 American cities, 22 of which were practicing time-of-day pricing at the time, namely, Akron (OH), Allentown (PA), Binghamton (NY), Burlington (VT), Chapel Hill (NC), Chico (CA), Cincinnati (OH), Columbus (OH), Denver (CO), Erie (PA), Louisville (KY), Minneapolis-St. Paul (MN), Orange County (CA), Sacramento (CA), Salt Lake City (UT), Seattle (WA), Spartanburg/Anderson (SC), Tacoma (WA), Washington (DC), Wichita (KS), Wilmington (DE), Youngstown (OH) and ten other cities that had discontinued time-of-day pricing, namely, Albuquerque (NM), Baltimore (MD), Boston (MA), Duluth (MN), Kansas City (MO), Palm Springs (CA), Rochester (NY), San Francisco – Oakland (CA), St. Louis (MO), and Walnut Creek (CA). The paper described the system characteristics, fare structure, reasons for adopting time-of-day pricing, trends and impacts associated with time-of-day pricing, implementation issues, and the summary and prospects of the system. It also described the reasons for giving up on the concept in ten cities listed. The paper mentioned that the transit industry enjoyed increasing returns to scale, as in public utilities, and hence justified the time-of-day pricing. The justification is supported by marginal and average cost curves superimposed in order to compare the flat and differential fare systems. The paper, in addition, also published the results of the National Transit Fare Pricing Survey. In another paper, "Transit Pricing Research", Cervero (1990) suggests that the changes in service parameters will have a greater effect on the ridership trends than changes in fare alone. Also, changes in automobile prices will also affect the transit ridership to an extent greater than the fare changes in transit.

Charles F. Manski in Spring 1979 in the paper, “The Zero Elasticity Rule for Pricing a Government Service”, investigated the properties of “zero-elasticity” rule, wherein the agency sets a price and observes the resulting usage, assumes that the demand is totally inelastic and replaces the initial price with the one calculated and then again observes the demand, reapplying the zero elasticity assumption. The results are presented on the dynamics of iterated use of this rule, and the convergence to a price solving the budgetary problem. This approach does not apply to transit most importantly as transit was not a government service in most states, and in the states that it is commuting is predominantly auto oriented.

Tranplan Associates, Environics Research Group, Synergistics Consulting Ltd and Price Waterhouse published a study for CUTA (Canadian Urban Transit Association), “Modal Shift to Transit Study – Summary Report, Edition 1” in July 1992, wherein they looked into the role of various tiers of government, public and private enterprise towards promoting the role and ridership on Transit Systems in Canadian cities, including Metros and non-metros. The paper listed the environmental depreciation factors of SOV driving as opposed to taking Transit, fuel economy, congestion levels and also looked into socio-economic, technological, funding trends while asking what could transit do differently in order to increase its use. The benefits are studied and conclusions drawn on the role of various agencies, reiterating the stance that transit alone is not the answer.

“Ashland Reduced Transit Fare Demonstration Project, Final Report, FHWA Special Project”, Rogue Valley Transportation District report in September 2000 looked into the impact of drastically reducing the fare structure for bus transit. The fares were reduced by 75% from $1.00 to 25c. Simultaneously, the district also increased the service level by increasing its fleet. The increase in ridership was studied, but the results were inconclusive as to the percentage of increase attributed to reduced fare and the percentage increase contributed by increase in service.

“The Demographics of Public Transit Subsidies: A Case Study of Los Angeles”, by Hiroyuki Iseki and Brian D. Taylor, November 2001 examined the ways that transit subsidy equity could be measured and proposed a precise method for measuring subsidy of individual transit trips using service consumption and travel survey data from Los Angeles County MTA and other multi-cost factor cost allocation models developed in the earlier part of the research concluding that the distribution of transit costs and benefits among transit users is regressive with respect to income, than was two decades ago. Consequently the higher income, Anglo, Asian, older males were disproportionately subsidized raising questions of equity and objectives of transit policies.

“Transportation Pricing Strategies that Work”, testimony of Michael Replogle, Transportation Director, Environmental Defense at Highway and Transit Subcommittee, US House of Representatives, on May 23, 2001 favored the adoption of the following bills: H.R. 1815 making fuel efficiency standards for light trucks equal to that for cars, H.R. 318 providing equal tax treatment for parking and transit benefits, H.R. 1265 allowing employees who bike to work the same financial incentives as transit users, and H.R. 906 providing 25% tax credit to employers for cost of providing transit benefits to their employees. He highlighted the proposal of time-of-day tolls and High Occupancy Toll lanes (HOT lanes), while mentioning the electronic toll collection system in place at various cities in the US. He also talked about the land use patterns wherein Smart Growth could be promoted. All the listed measures in combination would work to curtail congestion and pollution while supporting a strong economy.

In an article in CATO Regulation, The Review of Business and Government, “The Bay Bridge Blunder”, Stephen Shmanske looks into the proposal of pricing the Bay Bridge facility in order to combat Congestion as well as a means to subsidize transit and paratransit. This was stated as mostly a road pricing initiative with cross-subsidy options.

Todd Litman, VTPI, in February 2005 in his paper, “Transit Price Elasticities and Cross Elasticities”, listed various studies in transit fare elasticity and cross elasticity, starting with the Simpson-Curtin Rule of thumb, through various studies from 1991 to 2003. The research is summarized and numerous elasticity tables are presented with different independent variables. Service elasticities and multi-modal elasticities, direct and cross elasticities, as well as elasticity with respect to fuel prices, parking prices, parking provisions are also mentioned. Conclusions are drawn and recommendations made as to the best practice elasticities for various types of geographical and situational conditions. The study does mention that elasticities are highly inherent; implying that no single transit elasticity value applies in all situations.

In the article, “Transit Subsidies not Cost-Effective”, on July 17, 2005, Ted Balaker studies the difference in rail and bus transit subsidies and equity issues. According to the author, bus transit is a better means of transport for the poor and is being neglected in comparison to its sleek counterpart, rail transit. The point in argument is that political entities and other parties look on subsidizing rail transit in order to steer wealthy people out of their cars, and this money gets channeled out of bus transit which, not better to begin with, gets worse. The article mentioned the escalating costs of rail transit vis-à-vis bus, mentioning that this does not solve the problem of congestion as the wealthy can afford two cars to get to work – one from home to transit station parking, the other from station parking to office and vice-versa.

Most importantly, TCRP in Research Results Digest provides a summary of TCRP Project H-6, “Transit Fare Pricing Strategy in Regional Intermodal Transportation Systems” Report 95. The report strongly proposed the case for coordinated intermodal pricing suggesting that the transit and highway pricing should be complimentary and reflect the goals of the region. The report explained the various transportation costs, subsidies and distribution of revenues. It also proposed a conceptual approach to intermodal pricing, development of coordinated pricing strategies and sharing of revenues while, at the same time, recognizing the institutional barriers. The report also cited studies for transit elasticities, cross-price elasticities and auto elasticities, as well as cross-price elasticities of transit use with respect to auto price, as case study examples. The report attaches in Appendix B, examples of selected transit pricing and subsidy programs specifically in relation to inter-modal pricing scenarios. The examples citied are Chicago, Southeast Florida and Orange County, CA. Integrated Fare Payment examples are San Diego and San Francisco Bay Area. Effects of subsidy programs are studied in New York, Milwaukee and San Francisco. Other programs promoting employer fare subsidies are listed from CA, New York, CT, Delaware and NJ. Appendix C studies the application of Inter-modal price coordination impact assessment methodology by considering various hypothetical cases.

The elasticities and cross-elasticities of transit are studied in the papers that follow. Most important among them is the research paper by Todd Litman from the Victoria Transport Policy Institute (VTPI), “Transit Price Elasticities and Cross-Elasticities”, published in the Journal of Public Transportation, June 2004, summarizes the price elasticities and cross elasticities for use in public transit planning. The transit elasticity values commonly in use are based on short and medium run studies performed when income levels were low and most of the population was transit dependent. Mentionable here would be the study of the 32 US cities, cited earlier in the review. According to Litman, “Analysis based on these elasticity values tends to understate the potential of transit fare reductions and service improvements to reduce problems such as traffic congestion and vehicle pollution, and understate the long-term negative impacts that fare increases and service cuts will have on transit ridership, transit revenue, traffic congestion and pollution emissions”. Litman lists some of the factors that affect transit elasticities as: User type, Trip type, Geography, Type of price change, Direction of price change, Time period, and Transit type. The following table lists the bus fare elasticities published by the American Public Transportation Association, listed in Pham and Linsalata, 1991:

Table 2: Transit Elasticity (City Size)

	Large cities (more than one million population)	Small cities (less than one million population)
Average for all hours	-0.36	-0.43
Peak hour	-0.18	-0.27
Off-peak	-0.39	-0.46
Off-peak avg.	-0.42	
Peak hour avg.	-0.23	

Another set of elasticities summarized in the paper were bus fare elasticities reproduced from a major UK study by Dargay and Hanly (1999, p.viii) and are tabulated below:

Table 3: Transit Elasticity (Time Period)

Elasticity type	Short run	Long run
Non-urban	-0.2 to -0.3	-0.8 to -1.0
Urban	-0.2 to -0.3	-0.4 to -0.6

Litman, as a conclusion to the study recommends the following transit elasticity values that should be modified as appropriate reflecting specific conditions:

Table 4: Transit Elasticity (Fares, Service & Auto Costs)

	Market Segment	Short term	Long term
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
Transit ridership wrt transit fares	Suburban commuters	-0.3 to -0.6	-0.8 to -1.0
Transit ridership wrt transit services	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

There have been two studies of the fare-free program, the BruinGO Program at the UCLA and the U-Pass program in Washington. Both the studies reported ridership increases in double percent points. The following table illustrates the effects of BruinGO on commuting from inside the Blue Bus Service area, where the program is applicable:

Table 5: Change in Bus Riders (BruinGO Study)

	Medium estimate		Low estimate	
	% change	**Number**	**% change**	**Number**
Faculty/staff bus riders	+134%	+854	+128%	+818
Student bus riders	+43%	+1,248	+13%	+384
Total bus riders	+56%	+2,102	+33%	+1,202
Faculty/staff solo drivers	-9%	-304	-8%	-260
Student solo drivers	-33%	-992	-26%	-760
Total solo drivers	-20%	-1,296	-16%	-1,020

The underlying table gives the discrepancy between the predicted and the actual ridership percentage points in the U-Pass program:

Table 6: Forecast vs. Actual Ridership (U-Pass Study)

<table>
<tr><th></th><th>Predicted percentage change in ridership</th><th>Actual percentage change in ridership</th></tr>
<tr><td rowspan="4">Transit service Improvements</td><td>#99 B-Line (10%)</td><td rowspan="2">135%</td></tr>
<tr><td>#99 Non-stop (70%)</td></tr>
<tr><td>#41 Joyce (2.1%)</td><td>78%</td></tr>
<tr><td>#480 Richmond (9.7%)</td><td>90%</td></tr>
<tr><td rowspan="3">Fare</td><td>MC=0 (35%)</td><td rowspan="3">35%</td></tr>
<tr><td>AC, 5X a week (23.9%)</td></tr>
<tr><td>AC, 2X a week (17.5%)</td></tr>
</table>

The percentage changes in both the fare-free programs surely need to be studied in detail, especially when accompanied with the benefit-cost ratios of 4:1 (BruinGo).

Although the studies listed above present a general overview of published work on transit fare and time-of-day pricing, these are not isolated. All these papers are based on many other interdisciplinary references and work ranging from economics, econometrics to transportation. There is no dearth of work done on time-of-day pricing economics, theory and practice. The aim should be to integrate the studies in order to assess our objectively innovative approach to transit pricing.

<u>Research Objectives:</u>

This research is an attempt to get answers to the following questions:

1. What is the peak and off-peak hour ridership on bus in Westchester County, NY?
2. Is the service congested during peak periods?
3. What is the practiced pricing structure/fare structure in the County for bus transit? Do the modes complement each other with their pricing, or is the pricing in isolation?
4. What is an optimal price/fare structure for transit inherent to Westchester County, NY that will optimize the usage of the service at all times, peak and off-peak?
5. Will time-of-day pricing that might be currently in practice, still be the optimal approach?

6. If a change is required, will the price differential increase/decrease? What will be effect on the revenues for bus transit?

7. Develop a model wherein the price structure is optimized for the mode.

As the focus of this study is transit pricing with approach towards congestion mitigation and spreading the peak, incorporated in this study will be the concept of modal transfer, which in itself is another research project. The objectives of this study warrant further research into the interdisciplinary subjects of economics, econometrics and highway transportation and compare transit, both volumetrically and economically, with other modes in transportation and other arenas unrelated to transportation, understanding the concepts behind the theory and application, and developing similar mathematical models, though integral to transit.

5. Temporal Fares in Bus Transit Systems Past and Present

5.1 Introduction

Transit is a form of mass transportation that is underutilized in the United States at present, with people's preference for owning or traveling in single occupancy vehicles (SOV). Hence, with very few exceptions, transit's is a captive commuter market. The efforts are affront to counter this trend and make transit more viable and attractive alternative.

Throughout the seventies the trends showed an increase in the transit share of transportation market. The eighties heralded a spiraling downturn with decrease in gas prices and other exogenous factors, making it increasingly difficult for commuters to patronize high priced, fixed route transit. In addition to the already falling market share, the anticipation of federal cuts on transit subsidy necessitated the experimental phase of fare schedules in many transit systems. The goals were either

- Increasing farebox returns, or
- Distributing the ridership in order to better performance characteristics, or
- Enhancing the mobility of the elderly, handicapped and lower income group.

These and other similar interests led to the experiment with temporal delineation of fares. Some of the experiments died a natural death with the objectives and goals not being fulfilled. Others are still ongoing and successful.

This paper highlights all these experiments, both in the past and present, specifying the reasons for

- Fare variation
- Reasons for continuation
- Reasons for demise (whenever available).

The data for these studies came from the in-depth

- Study of the transit system websites,
- Conversations with transit system officials
- Robert Cervero's Case Studies Appendix for USDOT study in 1984 mentioning 32 cities.

A rigorous effort has been made to follow each of the 32 cities, and incorporate any others, in order to ascertain the progression of temporal pricing programs.

This is also an exercise to provide a comparative basis of these systems to Bee-Line transit system in Westchester County, NY with a view to study and feasibility and impact of a temporal fare structure option.

The Bee-line transit system operates on 36 regular local routes, 3 summer routes, 9 commuter rail link routes, 9 express routes, 9 shuttle service lines, 9 connecting bus routes and 8 subway routes. The temporal fare option being considered is an exercise to better the riding comfort and safety for the E&H (elderly and handicapped) commuter group.

Westchester County demographic trends (total and elderly population) are shown in Table 7.

Table 7: Population trends in Westchester County

Year	Population	Elderly
1900	184,257	
1910	238,055	
1920	344,436	
1930	520,947	
1940	573,558	
1950	625,816	
1960	808,891	
1970	894,104	
1980	866,599	
1990	874,866	94,548
2000	923,459	129,300

Ridership trends are presented in Table 8

Table 8: Ridership Trends on Bee-line System

Year	Total Ridership	E&H
1997	29,490,607	2,180,831
1998	29,664,134	2,168,876
1999	29,418,927	2,082,636
2000	29,744,701	2,036,975
2001	29,478,778	1,900,593
2002	29,310,001	1,820,177
2003	27,740,084	1,778,322
2004	27,864,065	1,835,762
2005	24,947,454	1,547,887

5.2 Historical temporal pricing

Erie Metropolitan Transit Authority serving Erie, PA is the pioneer of time-of-day differential in US. EMTA operates about 17 routes today.[5] EMTA started with this program in 1972 with a 10 cent differential. Studies conducted thereafter indicated the fare elasticity of the system to be in the range of -0.5 to -0.9. This is fairly high to the anticipated -0.3 elasticity for bus transit systems indicating that riders changed their travel in response to the differential. The program goal of increasing system wide ridership was not achieved[1]. EMTA continued its program to sometime after 1984 when it was reverted back to the flat fare structure. The system is considerably smaller than Bee-line, in terms of routes being operated.

Metro Regional Transit Authority (Metro RTA) serves the Summit County in Ohio with 43 routes inclusive of express routes, grocery routes and late night bus shuttle. Metro RTA followed the example by EMTA by creating a 5 cent differential. The fares were lowered from 40 cents to 35 cents during most times of the day and 25 cents during midday hours (Monday – Friday, 10am – 2pm). With various fare increases the program continued till 1981 after which the flat fare system was instituted in anticipation of federal subsidy cuts. The differential was reinstated with a 5 cent differential (50 cents during midday and 55 cents rest of the day). The reasons prompting price differential was the desire to fill the empty midday seats. It was thought that the differential would increase the system ridership. Change in fare schedule increased the ridership by an estimated 5-6% corresponding to elasticity of -0.4 with no fiscal gains/impacts. Revenue gains were marred by increase in operating costs leading to deterioration in recovery ratio. Significant improvement was noted in operating performance in 1973 with cost per vehicle mile and per vehicle hour registering absolute decreases[1]. The last noted fare increase was in early 1990's listing a flat fare structure[6]. This system is relatively closely related to Bee-line in terms of operating routes.

Chittenden County Transit Authority (CCTA) for Burlington, VT operated on the shore of Lake Champlain in north VT with a fleet size of 47 buses and 5 member municipalities – Burlington, Essex, Shelburne, South Burlington and Winooski. The system operates 20 routes including the express service routes. It also operated grocery shopping service shuttles and neighborhood special service routes[9]. It serves a population of 146,571 (2000) with an elderly population of 10.2% (2000). Comparatively CCTA operates a system smaller in scope (population and routes) to the Bee-line in Westchester County. CCTA initiated temporal fare differential in 1976 wherein the off-peak fare was reduced from 35 cents flat to 25 cents, creating a differential of 10 cents[1]. This differential was widened or maintained in all the fare schedules from 1976 to 1984, but did not continue for much longer after and flat fares are again visible. Reasons for the fare differential were:

- Changing the ridership patterns to off-peak in order to fill the empty midday seats
- Increase the overall system ridership.

The data in the following year indicated a 16% increase in off-peak riders with positive indication of overall ridership gains. Fare change alone accounted for 10% increase in ridership. A survey conducted in 1983 indicated that

- 94% adults were aware of the differential,
- 45% of them planning with the differential in mind.
- 88% indicated that they have taken advantage of the discounts.

CCTA was indicative of a small transit operation which managed to differentiate fares while maintaining a cost recovery ratio in excess of 50%[1]. The operator now offers a flat fare structure.

Chapel Hill Transit (CHT) serves Chapel Hill, NC having a population of 48,715 (2000) and elderly population of 8% (2000) operating 26 routes with 83 fleet size and 11 lift equipped vans[10]. The system started the temporal differential program in August 1982 with a peak surcharge of 10 cents. The surcharge was an attempt to:

- Increase revenues and

- Shift riders to off-peak times.

Although ridership increased in the following year by 12.4%, the system costs rose sharply by 80.7% negating the positive impacts of the differential. The CHT now offers fare free service for local routes[1]. The express service and shared ride evening/ Sunday service are priced separately[10].

Butte County Transit operating in Chico, CA is a small urban and inter-city bus company operating 20 routes inclusive of its service to Paradise Pines and Oroville[11]. Population served by the system is 203,171 (2000) with an elderly component of 14.9% (2000). The differential was adopted with the aim of increasing revenue without discouraging peak usage[1]. The continuation of the program was already uncertain at the time of 1984 Cervero study, and as the revenue gains were not realized, the differential is not in effect now[11].

South Ohio Regional Transit Authority (SORTA) with operations in Hamilton County (2000 population – 845,303; 2000 elderly population – 13.5%) and parts of Butler, Clermont County (2000 population – 177,977; 2000 elderly population –10.3%) and Warren County with a fleet of 390 metro buses over 44 local routes, 26 express routes and 7 "job connection" routes[12] is comparable in size and operation to the Bee-line system. The system increased the base fare of 25 cents to 35 cents during 6-9am and 3-6pm and 30 cents for all other times in 1978. In 1981 this differential was increased to 10 cents. The reasons behind the program were:

- To entice riders to off-peak with hopes that once they started using the system they will continue to patronize it.
- Assist the elderly and lower income residents by holding down off-peak rates
- Encourage ridership shifts while designing fares as to more closely recapture costs
- Achieve a farebox recovery target of 45%.

SORTA associated efficiency gains noticeable after to time-of-day fare policies. The differential was supposed to be widened as there was a very low fare evasion rate and the "moderate success"[1].

Central Ohio Transit Agency (COTA) has a fleet size of 274 buses traveling throughout Franklin County on 63 routes[13] making it just right for comparison to the Bee-line system. COTA was planning to propose a dedicated sales tax to offset the rising costs, but the bill was narrowly defeated. The recourse was to increase the fares and add a 15 cent surcharge from express users. Aggressive marketing led to the passing of the 0.5% dedicated tax for transit in 1980 with the promise of reducing the off-peak fare to 25 cents. The differential was more of an obligation to the community. It was started as a part of the "Incentive Fare Program" and it included the creation of a two mile fare free zone. The transit service was provided free of charge within the two mile zone between the hours of 9:30 am to 3:00pm. Outside the zone the fare was a quarter. Peak hour fares were 60 cents for local service and 75 cents for express service. This was the greatest price differential at the time. The reasons for the price differential were:

- To increase the midday ridership to the underutilized capacity period.
- Strengthen the downtown and core business community
- With the peak period services at capacity or above, it was also hoped to shift some riders to off-peak periods

- Increase the system wide ridership

This initiative was a part of the greater effort to revitalize the downtown area. Results were fairly dramatic with the CBD trips increasing by 1/3rd and outside the CBD the increase in midday trips was 102%. The overall midday riders share increased from 36% to 48% within two years.

The price elasticity derived from models was -0.94, quite high by transit standards. The more remarkable gains came from sales tax receipt gains, putting the agency on financially sound footing. The main problem was collecting the quarter while leaving the fare free zone. With ridership rising, finances coming in, it was the most successful program of its kind[1].

Regional Transit District (RTD) operating about 160 routes today, catering to a local population of 554,636 (2000) and elderly population of 62,426 (2000)[14], it is an example of a system bigger in operation than the Bee-line in comparison. RTD of Denver, CO adopted the program in order to:

- Spur ridership increases
- Shift riders in order to improve regional air quality
- Reduce highway congestion
- Promote equity
- Encourage the use and purchase of tokens

Peak hours were from 6:00am to 9:00am and from 3:00pm to 6:00pm. Ridership trends showed promise and also financial viability. A part of the reason of initiating the program was to encourage the purchase and use of tokens; it might have been a short-time promotional strategy to get the commuters to think in terms of tokens and multiples[1].

Transit Authority of River City in Louisville, KY got the time-of-day pricing program in inheritance from privately owned and operated Louisville Transit Agency that was acquired in 1974[1]. TARC has been a major public transit provider for Jefferson, Oldham and Bullitt counties since 1974. In response to the initiative:

- The patronage of lower income group increased to 18%
- Transit captive ridership dropped from 87.5% to 61.7%
- Notable increase in senior usage of the system.
- Leveling off of off-peak ridership numbers
- Fiscal improvement of property[1].

TARC has a flat fare system now[15].

Orange County Transit District for CA introduced time-of-day pricing on both local and dial-a-ride on July 1, 1981 with the peak hours being from 6 – 9am and 3 – 6pm. Primary goal was to achieve 20% farebox recovery ratio. The differential, however, had no effect on system ridership or finances[1]. OCTD now offers a flat fare structure[16].

Regional Transit, Sacramento, CA operating 119 bus routes[17] is one of the most comprehensive systems studied. The system designated the peak period from 6:30 – 9:00am and 3:30 – 6:00pm with a peak period surcharge. The main reasons for fare increase were:

- Recognition of the increase in operating costs during peak period
- Encourage elderly, handicapped and students to ride off-peak when there was capacity available.

The ridership declined by 14.6% after the inception of the differential, while the peak hour ridership went up by 23%. Decrease in overall ridership was attributed to slow economy and decreasing gas prices. The objective of increasing the revenues was mainly achieved by tapping the pockets of peak period commuters[1]. RT does not offer any fare differential now[17].

Utah Transit Authority, Salt Lake City, UT always had a history of low fares[1]. UTA serves six counties – Salt Lake County with 90 routes, Weber County with 19 routes, Davis County with 15 routes, Box Elder County with 2 routes, Tooele County with 4 routes and Utah County with 18 routes in addition to three routes for TRAX, 15 night rider routes and 8 ski routes[18]. In July 1981 the off-peak was set at 40 cents and the peak at 50 cents due to a political decision to placate highly vocal groups of seniors and students. Ridership declined by 15.2% following the introduction. Strict control on the costs improved the financial situation. Riders became increasingly choice commuters and the captive ridership declined[1]. By 1984 UTA was considering discontinuing the program and, not surprisingly, it is not in effect today[18].

Pierce Transit serves the Pierce County in Tacoma, WA with a population of 700,820 (2000) and an elderly population percentage of 10.4% (2005). It operates along 47 different routes[20]. The transit system introduced time-of-day fare schedule in January 1982 with the primary reason of equity as the provision of peak period service costs more and should be charged accordingly. The year following the inception the revenues were believed to have risen by 42.5%, but cannot be authenticated due to lack of data[1].

The fifth largest bus network in US today, **Washington Metropolitan Area Transit Authority** serves a population of 572,059 (2000) in Washington, D.C. and 969,749 (2000) in Fairfax County, VA with the elderly population contributing 12.2% (2000) and 8.8% (2005) respectively. The system is operating a fleet of 1460 buses, 12,435 stops over 350 routes on 182 lines today[21]. The program of reduced off-peak fares was the most well documented and well publicized, mainly due to Washington being the country's capital. The program was implemented in September 1975. The fare structure was fairly complex and changed too frequently rendering the differential redundant. The reasons for adopting the differential were as varied as the different incarnations of the program. The off-peak shift that was hoped for never materialized and there were no financial gains or performance gains. The program was very vocally criticized for its complexity, the definition of the peak and the unnecessary inequities[1]. It is not surprising that the system now offers a flat fare structure.

Wichita Transit with 18 operating routes[22] serves a population of 344,284 (2000) and an elderly population of 11.9% (2000). The property offered a price differential in January 1983 by offering midday discounts between 9:45am – 3:45pm after being criticized for not paying its way. The goal was to achieve a 30% farebox recovery and exacting more from the inelastic peak, while maintaining the elastic off-peak commuters[1]. The program was well received and had hopes of continuation.

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All the systems mentioned above have discontinued the fare differentials. In some cases, very successful programs have been halted. Rigorous efforts of the author to find reasons behind their demise have not been fruitful. The effort will be continued, however, on another platform in the future.

Delaware Administration for Regional Transit (DART) for Wilmington, DE serves three counties,

- New Castle County having a population of 500,265 (2000) and an elderly percentage of 11.5% with 43 routes,
- Kent County having a population of 126,697, 12.3% of them being 65+ (2000) with 13 routes, and
- Sussex County having a population of 156,638 (2000) and 19.4% share of the elderly with 3 routes.

In addition, there are 2 inter-county routes[23]. DART initiated temporal differential in 1981 where off-peak was defined as being from 9am to 3pm and all Saturday[1]. The differential was only applied to strip tickets, with the following goals in mind:

- The peak period rides cost more to operate and therefore should be suitably charged in order to be equitable.
- There was a desire to increase midday ridership when there were many seats available
- In order to shift the discretionary peak riders to the off-peak making the peak ride less congested and more comfortable[1].

The fare differential was introduced in conjunction with complete overhaul of DART's route and fare structure. The overhaul resulted in

- Increase in passenger revenue and average fares
- Modest gains in farebox recovery ratio
- Decline in level of service
- Substantial decrease in system ridership[1].

The apparent failure of the program led some policy makers to re-question its rationale. And that was the reason of the demise of the differential at DART.

Western Reserve Transit Authority for Youngstown, OH caters to a population of 82,026 including an elderly population of 14,299 (2000) with 20 different routes including a nightline service[24] and is a very small system in comparison to Bee-line. The fare differential was introduced in 1979 and discontinued in 1980. The program was reinstated in 1982 in order to promote downtown shopping/commercial activity[1]. The program was a short-term policy measure and was discontinued shortly after.

SunTran in Albuquerque, NM caters to a population of 448,607 and about 12.0% of the elderly with 33 routes throughout the region[25]. The experimentation with fare differential continued from July 1980 to June 1981, without any noticeable ridership changes[1]. The staff of the property was not in favor of continuing with the program[1] hence the flat fare schedule today is not a surprise.

MTA in Baltimore, MD operates more than 50 local bus lines many of which connect with light rail, subway and MARC train service[26] to cater to the demand of a population of 651,154, 12.1% of which are over 65 (2000). The system is somewhat comparable to Bee-line demographic base. MTA adopted a peak hour surcharge of 5 cents. The main reasons of the differential were:

- Equity
- Farebox recovery ratio
- Minimizing overall ridership loses.

The program was abandoned due to inadequate revenue generation and implementation problems[1].

Massachusetts Bay Transit Authority for Boston, MA operates 175 routes[27] today in response to the demand from 589,141 people including 61,336 elderly (2000). It was one of the largest transit systems in the US to attempt temporal fare differential on April 2, 1973 with the primary objectives of:

- Increasing off-peak ridership and
- Flattening the peak

The program was discontinued due to increasing revenue loses to revenue. The differential was not having the desired effect[1].

Kansas City Area Transit Authority in MI serves over 77 routes[28] making it the most close comparison to Westchester County. The population is far from comparative, though, at 441,545 including an elderly population of 51,692 (2000). The system adopted the policy in January 1982 in order to facilitate equitable travel[1]. The program was dropped due to Union pressures and public confusion[1].

Sunline Transit for Palm Springs, CA with 12 lines in service[29] established time-of-day pricing in October 1981 with an aim of enticing off-peak riders. Sunline, however, discontinued the practice in September 1982 due to revenue losses[1].

The reasons for discontinuing the experiment are telling towards the pitfalls that could be encountered. The property should be prepared to deal with these in order to turn the failures in to successes. There are no guarantees offered towards the success of such programs, as the spectrum of transit systems have experienced. The systems with failures are not restricted to the small systems in terms of either population or fleet or routes. Nor are they primarily categorized as large systems. Hence, the conclusion that the failures are dependent on the size of the system or its population base cannot be justified.

5.3 Contemporary Time-of-day Fare Schedule Programs

The success stories present a similar picture in terms of transit property size and demand base. The following is a discussion of the systems that are still continuing with the experiment and of the systems that have joined the bandwagon since the 1984 Cervero study.

Metropolitan Transit Commission, now Metro Transit operating in the twin cities of Minneapolis – St.Paul in MN has a spectacular history of continuing with the temporal fare differential since its inception in June 1982. The temporal differential was in response to the legislature bill putting a statuary ceiling on transit fares with the option of levying peak period surcharges in July 1981. Hence, the legislature limited the MTC's price changes to the peak periods only[1]. The zonal fare structure is complex. Table 9 presents the fare structure for Zone 1 in July 1983.

Table 9: MTC Fare Structure (July 1983)

(Zone 1 only$_1$)

Fare Type	**Peak$_2$**	**Off-peak**
Adult	0.75	0.60
Youth	0.75	0.20
Sr. Citizen	0.75	0.10
Handicapped	0.75	0.30
Dime Zone (Minneapolis – St. Paul CBD)	0.10	0.10
Pass cards	24.00	24.00-50.00

Reference: Cervero, Robert; Evidence on Time-of-day Pricing in United States, Volume 2: Appendices and Case Studies, US Department of Transportation, May 1984

Footnotes: 1. fares prorated upwards from travel zones 1 and 2, 3, 4 and outside the city limits

2. Peak hours in effect from 6:00 to 9:00am and 3:30 to 6:30pm all weekdays.

Although the MTC staff and management were opposed to the price differential, they had no option left in wake of the State Legislature. Section 473.408, subdivision 2 of the governing transit fare policy stated:

"Fare and fare collection systems shall be established and administered to accomplish the following purposes:

a) to encourage and increase transit and Para transit ridership with an emphasis on regular ridership;

b) to restrain increases in the average operating subsidy per passenger;

c) to ensure that no riders on any riders on any route pay more in fares than the average cost of providing the service on that route;

d) to ensure that operating revenues are proportioned to the cost of providing the service as to reduce any disparity in the subsidy per passenger on routes in the transit system; and

e) to implement the social fares as set forth in subdivision 3 which dictates a $0.20 base fare for students, 50% of full fare for handicapped and $0.10 fare for senior citizens 65 and older"[1].

The statute was to expire in July 1985[1]. The legislature still exists in some form, not immediately available for quoting. Today the fare structure is pretty simple, but still retains the differential as can be inferred from the table 10.

Table 10: Fare Structure at MTC (Jan 2006)

Fare Type		Non-rush hours	Rush hours
Adults (ages 13 - 64)	Local	$1.50	$2.00
	Express	$2.00	$2.75
Seniors (65+) Youth (6 – 12) Medicare card holders	Local	$0.50	$2.00
	Express	$0.50	$2.75
Persons with disabilities	Any trip	$0.50	$0.50

Reference: www.metrotransit.org

Rush hours: Monday – Friday 6:00 – 9:00am and 3:00 – 6:30pm. Local fare is charged on light rail.

Downtown zone: The fare for riders within the Minneapolis or St. Paul downtown zone is 50 cents at all times. Transfers are not available with Downtown Zone fares.

A system survey in January 1983 indicated that 54.8% of the riders traveled during peak periods and 45.2% during off-peak[1].

Today, MTC recovers 35% of its budget from farebox revenues, 60% comes from State appropriations and Motor vehicle sales and the remainder from federal and self-generating resources[37].

MTC does not have any dedicated funding for transit necessitating the officials to go to the legislature year after year, sometimes facing reductions, leading to fare increases and service reductions. A public referendum was put up for consideration in November 2006 wherein all the proceeds from vehicles sales are being asked to be routed to transportation, both highway and transit. The agency now offers base fare, peak fare and express fare policy. Although 35% farebox recovery is still the standard and goal, the recovery average is about 30%. Table 11 shows the fare increases in recent history[41].

Table 11: Metro Transit Fare History

Years of change	Regular fares						Social Fares		
	Base	**Peak (+)**	**Exp (+)**	**Pk Exp**	**Max Zone**	**Discount**	**Youth**	**Seniors**	**Lt. Mobility**
1970	$0.30		$0.05		$0.50	$0.00	Free	Free	
1975	$0.30		$0.05		$0.25	$0.00	$0.10	Free	$0.15
1976	$0.30		$0.10		$0.20	$0.00	$0.10	Free	$0.15
1977	$0.30		$0.10		$0.25	$0.00	$0.10	Free	$0.15
1979 July	$0.40		$0.10		$0.25	$0.00	$0.10	Free/0.10	$0.15
1980 Apr	$0.50		$0.10		$0.25	$0.00	$0.20	Free/0.10	$0.20
1981 July	$0.60		$0.10		$0.40	$0.00	$0.20	$0.10	$0.20
1982	$0.60	$0.15	$0.10		$0.40	$0.00	$0.25	$0.10	$0.25
1989	$0.50	$0.25	$0.25		$0.25	$0.00	$0.25	$0.10	$0.25
1991	$0.85	$0.25	$0.25		$0.25	$0.30	$0.25	$0.25	$0.25
1993 Jun	$0.85	$0.25	$0.25		$0.25	$0.25	$0.25	$0.25	$0.25
1993 Dec	$1.00	$0.25	$0.50		$0.00	$0.20	$0.25	$0.25	$0.25
1995 Nov	$1.00	$0.25	$0.50		$0.00	$0.20	$0.50	$0.50	$0.50
1996 July	$1.00	$0.50	$0.50		$0.00	10%	$0.50	$0.50	$0.50
2001 July	$1.25	$0.50	$0.50		$0.00	10%	$0.50	$0.50	$0.50
2003 Aug	$1.25	$0.50	$0.50	$0.25	$0.00	10%	$0.50	$0.50	$0.50
2005 July	$1.50	$0.50	$0.50	$0.25	$0.00	10%	$0.50	$0.50	$0.50

Reference: Wallace, Lynn; Supervisor, Revenue Ridership Analysis, MTC, MN; communicated via email.

Municipality of Metropolitan Seattle in Seattle, WA or **Metro Bus Transit**, introduced time-of-day pricing in February 1982 with a 10 cent differential for trips within one zone and 15 cent differential for trips between zones[1] as shown in Table 12.

Table 12: Seattle Metro Fare Structure (as of July 1983)

Fare Type	Peak Fare[1]	Base Fare
One Zone[2] – Cash	$0.60	$0.50
Two Zones – Cash	$0.90	$0.75
One Zone – Mon. Pass	$23.00	$19.00
Two Zones – Mon. Pass	$34.50	$28.50
One Zone – Ann. Pass	$253.00	$209.00
Two Zones – Ann. Pass	$379.50	$313.50
Youth – One/Two Zones	$0.60	$0.50
Elderly/Handicapped	$0.15	$0.15

Reference: Cervero, Robert; Evidence on Time-of-day Pricing in United States, Volume 2: Appendices and Case Studies, US Department of Transportation, May 1984

1. Inbound: 6-9am and 3:30-6pm; Outbound:6-8:30am and 3-6pm weekdays only
2. Zone boundary coincides with municipal boundary.

Today the King County Metro Bus fares as of June 1, 2005 are as presented in Table 13:

Table 13: Fare Structure at King County Transit (June 2005)

King County Metro Fare Type	Cash fare per trip	One month PugetPass	Three month PugetPass	Annual PugetPass
Metro Youth (6 -17)	$0.50	$18.00		
Metro one & two zone (off-peak)	$1.25	$45.00		$495.00
Metro one zone (peak)	$1.50	$54.00	$162.00	$594.00
Metro two zone (peak)	$2.00	$72.00	$216.00	$792.00

Reference: www.transit.metrokc.gov

The municipality put in considerable effort while deciding to opt for time-of-day fares. The results expected by transit officials in 1983 included the following[1]:

- Small anticipated ridership impact relying on Lago et al's (1980) work on average fare elasticities.
- Operational simplicity as the peak hour surcharge was not expected to pose any problems to the staff as well as the commuter.
- Jurisdictional Equity expected to produce an acceptable deficit distribution between City of Seattle and King County.
- Effect on low income population – it was felt that this program would favor low income groups

The municipality conducted wide spread on-board surveys before and after the implementation in order to extensively study the system-wide effects of the initiative. The study of financial data indicate that the farebox revenues increased in the year following the implementation, but fell again due to an increase in the operational costs[1].

However extensive the studies, there is no conclusive impact of time-of-day fares in Seattle. The program is deemed successful in meeting the revenue requirements of the system without any significant disruption[1].

After the 1982 introduction of peak period surcharge, the fares were increased in 1985, following which the ridership fell from 64.8 million to 63 million[42]. The next fare increase came about in 1988 and the ridership rebounded to 67.6 million. In 1991 the peak period fares were increased to $1.00 and $1.50 and the total ridership numbers were 74.6 million. The following year there was another surcharge of $0.10 with ridership at 74.6 million. The peak fares increased in 1998 by another 15 cents and 25 cents in 2001, with the ridership crossing the 100 million mark in previous year[42]. The implementation of the differential still provides enough revenues, in addition to providing a pleasant ride to the unemployed, elderly and handicapped while moving the fleet in an efficient manner. The 2001 increase includes a 25 cent peak period surcharge for seniors[42]. There have been complications with this policy as Metro Transit has an agreement with five agencies and offering five different fare structures, while Metro is the only one providing peak period surcharges. Efforts are afoot to streamline and simplify the fare structure. The fare box recovery is about 25% and the differential and zonal surcharges are the only sure revenue resource[42].

A revenue impact survey, conducted in September-October 1999 presented the following results:

- Given a choice between 40% increase in fares and service reductions, most regular riders would opt for fare increases
- If transit service were to be reduced, most regular riders as well as general public as a whole would like to have the rush period service preserved
- The top priority for roads among respondents would be to emphasize the maintenance rather than new construction to alleviate congestion or new safety measure like sidewalks and traffic lights[34].

Another 2000 on-board survey highlighted that commuters were willing to pay more in order to keep the revenues flowing.

The 2003 Rider/Non-rider Survey presented the following scenario to the county officials:

- 34% of Metro riders said that they relied on transit for most of their transportation needs, up from 28% in 2002
- 81% of the King County's residents walk to the bus stops, 92% of North King County residents walk compared to 67% from South King County and 58% from East. East King County residents prefer to park and ride (41%).
- 45% of the riders listed work as their destination for using transit, up from 41% in 2000 and 2001. Recreational transit travel fell from 24% in 2001 to 14% in 2003.
- 58% of the riders do not transfer when traveling to their destination, while 26% make one transfer and 16% make two or more transfers to get to their destination.
- Overall customer satisfaction with Metro Transit was 94% and consistent with the past performance[35].

Although Westchester County's Bee-line is a smaller system compared to Seattle, it is worthwhile to understand how this system works and what can be incorporated while planning similar measures for Bee-line.

Duluth Transit Authority started its tryst with time-of-day pricing in August 1980 when two types of monthly passes began to be issued, one of which was $3.00 less with the condition that it could not be used in the morning half hour peak of 7:30 to 8:00am. The pass was initially offered through employers who had less than 70% employees coming in to work between 7:45 and 8:00am. From August 1981 to 1982, when the pass was discontinued, it was sold to the general public. The reason for adoption was the intention to eliminate the sharp peaks and encourage flexible work hours. The reason it was discontinued was the inability of the initiative to achieve the stated objective[1]. DTA reintroduced the fare differential and the fare schedule is presented in table 14.

Table 14: Fare Structure at Duluth Transit (Jan 2006)

Fare Type	Peak Hours	Off-Peak Hours
Adult, Cash	$1.25	$0.60
Student (18 and under)	$1.00	$0.60

Reference: www.duluthtransit.com

DTA terms the peak period fares as worthwhile in terms of revenue, ridership as well as maintaining high level of service and efficiency. The $1.00 fare differential has been a catalyst in increasing off-peak ridership more than the loss of commuters during the peak, and saved DTA revenue for ID cards printing and issuing as off-peak periods offer half fare to all commuters. There are plans to continue with this fare structure in the foreseeable future[43].

DTA is a good candidate for in-depth comparative studies into policy and planning as the system has ventured into this initiative quite recently.

Anoka County in MN also operates a traveler (ACT) on three fixed routes – 801, 805 and 831 – on weekdays from 6:00 am to 8:00 pm except for 805 that operates on Saturdays from 8:00 am to 7:00pm as well[4]. The fare structure is as presented in Table 15.

Table 15: Fares[2] at Anoka County Transit (Jan 2006)

Fare Type	Rush Hour[1]	Non-Rush Hour
Adult (13 – 64)	$2.00	$1.50
Senior (65+)	$2.00	$0.50
Youth (6 – 12)	$2.00	$0.50
Persons with disabilities	$0.50	$0.50

Reference: www.co.anoka.mn.us/departments/transportation

1. Rush hours: Monday – Friday 6:00 – 9:00am and 3:00 – 6:30pm
2. Fares are one way

Although this is a very small service compared to Bee-line, it might still provide valuable insights into planning the resources for such an initiative.

Rhode Island Public Transit Authority (RIPTA) serves 38 of 39 Rhode Island communities, with 60 routes and a fleet of 240 buses through 24 park n' ride facilities. The funding for RIPTA comes from the following sources:

State – 39.3% (Gas Tax)

Federal – 17.3%

Other – 43.4%

(Reference: 2005 RIPTA Budget)[3]

The total ridership on all transit modes for 2005 was about 22 million passengers. RIPTA offers time-of-day fares in a unique format. It offers low income persons, elderly and handicapped free rides with the qualification that they possess a RIPTA NO FARE ID card. All other seniors pay full fare at peak times (7-9am and 3-6pm) on weekdays and half fare at all other times upon the presentation of a valid ID card[3].

The fare structure is presented in Table 16.

Table 16: RIPTA Fare Structure (Jan 2006)

Fare Type	Fares
Base fares for Buses and Trolleys	$1.50
Transfers	$0.10
Student Tokens	$12.75
Monthly Pass	$45.00
RIPTIKS	$13.50
Senior/Disabled No Fare	No Charge
Senior/Disabled Reduced Fare	$0.75
Senior/Disabled Transfers	$0.05
Express Park n' Ride	$1.50
ADA (Ride) One Way	$3.00

Reference: www.ripta.com

This system offers an idea for incorporating a similar practice in case of offering free rides to E&H commuter group for Bee-line transit.

Broome County Transit Authority in Binghamton, NY, north of the PA/NY border is a part of the Broome County Department of Transportation answering to the county executive and county legislature officials with 20 local routes in addition to long distance country bus routes as well as mini buses for paratransit[8]. The differential was implemented in July 1982 in order to enhance the farebox revenues with the special objective of attaining a 50% recovery ratio by 1986. The county came in to this idea with thorough research base that revealed high estimates for overall fare elasticity indicative of a flat rate increase being counter productive. Other secondary reasons included a hope of redistributing ridership to off-peak, better level of service indicators for peak commuters with lowering of headways and a qualification of similar farebox returns, if not more. The commissioners indicated at least a 10% increase in revenues. They believed some elderly to have moved to off-peak times. There was also an indication of reduced token sales, implying a move to reduced cash fares in off-peak times[1]. The county now offers a fare differential for local routes, but does not offer zonal differentials anymore. According to county transit director, George Bagnetto, a study done in 1986-87 had suggested implementing zonal surcharges in addition to the fare differential. There were problems with the enforcement of zonal surcharges faced by the drivers as well as some equity concerns and a lot of customer dissatisfaction despite the extensive outreach efforts[36]. Although a thoroughly researched experiment, it did not garner enough support and farebox recovery. The zonal surcharge was discontinued in 1995.

Transit today has pretty good ridership and sometimes experiences standing loads during peak hours. The fare differential is still in effect with a view to shifting the senior and handicapped commuters, including some recreational commuters to off-peak periods. This would make their ride more comfortable and pleasant. The system does not have any idea of the fare elasticites[36]. The total ridership during the AM and PM peak for the period between March 1, 2006 and June 23, 2006 was 291,868 and during the off-peak period for the same period are 508,075[45].

Broome County Transit is a relatively closer system to Bee-line in terms of geographical location and conditions. Meetings can be set up and planning and policy issues discussed in detail. The director of transit has been very forthcoming with the information and is keen on sharing his experiences.

The State of Pennsylvania, with collaborative efforts from the PA lottery, offers free rides to senior citizens during the off-peak hours designated to be between 8:00am to 4:30pm and 5:30pm to 7:00am weekdays and all day Saturday and Sunday on most of the PA transit properties. The peak period fares are one half of the adult cash fare. Every free senior trip is reimbursed by the PA lottery[2]. Notable among these is **LANTA** (Lehigh and Northampton Transit Authority for Allentown – Bethlehem – Easton, PA & NJ). The system serves a population of 334,176 inclusive of 15.4% seniors with 24 local routes, express service route and special evening shuttles. The system instituted variable fares in October 1972 with the lowering of 40 cent flat to 25 cent during 10am to 3pm on weekdays and all day Saturday[1]. The reasons for variably pricing the service were:

- Increase off-peak ridership
- Increase accessibility of transit dependent population

LANTA also introduced special fare for seniors in 1973, leading to an increase in senior ridership. A study conducted by LANTA indicated high fare elasticity for the off-peak riders, implying the commuters to be more receptive to price changes than their peak period counterparts. An increase in fares followed that reflected more increase in peak period fares than the off-peak counterpart. The decrease in off-peak ridership was such that it led to an overall decrease in system ridership[1].

Another important point to note in the experiment is that the schools in the region changed their schedules to allow the students to ride the system during off-peak times[1]. This is indicative of an impressive marketing campaign. Although the transit system returned back to flat fares sometime after 1984, it now adheres to the senior free fare program[7]. Among the accolades, LANTA won the National Ridership Award for 2003.

This transit property has an impressive marketing strategy and should be studied by Westchester in order to better promote their fare programs to the community.

There are other PA systems that can be mentioned, specifically New Castle Area Transit Authority offers the free ride program on all its routes except the Pittsburgh route.

The Port Authority of Alleghany County, PA does not offer free senior rides, but has a Fare Free Zone (CBD) wherein you can ride free between 4am and 7pm. The fare free zone was established to promote transit in Downtown Pittsburgh, encourage intramodal transfers and reduce boarding delays[46].

SEPTA (Southeastern Pennsylvania Transportation Authority) serving areas bordering NJ, also offers the free fare for seniors program, again being reimbursed for each trip by the PA Lottery[49].

Duke Power Transit for Spartanburg and Anderson in SC was a privately owned company, owned and operated by Duke Electric and Power Company[19] till 1992 when it was acquired by **SPARTA** (Spartanburg Area Regional Transit Agency). Duke offered off-peak passes on the system between the hours of 9am to 3pm with the primary motive being equity concerns. The program was moderately successful with little data available to authenticate the success[1]. SPARTA is again offering variable fares for senior commuters with the fares being $0.75 during peak periods and $0.50 during off-peak periods between 9am to 3pm[47].

Regional Transit Service in Rochester, NY, now called the **Rochester Genesee Regional Transportation Authority** oversees public transportation in Monroe, Genesee, Livingston, Orleans, Wayne, Wyoming and Seneca Counties[30]. Faced with an increase in capital costs in order to accommodate peak commuting in 1975, the system introduced variable fares to avoid capital investment with the intension of spreading the peak and utilizing off-peak available capacity[1]. The midday fare was reduced between 10am and 2:30pm. Subsequently, the desire to increase revenues became the prime objective. However, the NYCDOT became critical of the RTS's discounted fare policy, especially the fare free zone perceiving that the main beneficiaries were not the disadvantaged public but the commuting professionals who took advantage of the free service for lunch hour travel. This prompted the commissioners to vote for reversal to the flat fare structure[1]. After a recently conducted study pointed out the benefits of variable pricing citing the elasticity indices, the system has re-introduced variable fares. The system now offers half fares from 9am to 3:30pm and after 6:30pm during the weekdays and all day on Saturdays, Sundays and holidays[30].

This is another example of a system that can be visited, correspondence initiated and studies transferred because of geographical similarity and physical proximity.

Los Angeles County Metropolitan Transportation Authority offers variable senior fares. The off-peak fares are applicable to the times between 9am to 3pm and between 7pm to 5am in addition to all day on Saturdays, Sundays and holidays. This service is provided free. The peak period fares are equal to half the adult cash fare. Table 17 provides the fare schedule for the system[48].

Table 17: Metro Cash Fares (June 2007)

	Regular	Senior/Disabled/ Medicare
Base Fare (for each boarding)	$1.25	$0.55
Metro Day Pass (all day travel – zonal charges may apply)	$5.00	$1.80
Metro to Muni transfer (transfer to municipal lines)	$0.30	$0.10
Freeway express add-ons (on freeway routes) – **Zone 1**	$0.60	$0.30
Freeway express add-ons (on freeway routes) – **Zone 2**	$1.20	$0.60
Senior/Disabled off-peak base fare (weekday 9am-3pm and 7pm-5am, all day weekends and federal holidays)	Free	$0.25

Reference: www.mta.net/riding_metro/paying_fare.htm

The system is comparable to the New York MTA, and operates buses as well as rail transit[48]. The fleet size for the property is more than 200 and it is listed as a large transit system on the APTA website.

Charlotte Area Transit System provides service on 51 local/intercity routes and 21 express routes[50]. The system offers temporal fare of $0.65 for students through high school on local routes, contingent on presentation of a valid transit ID. The timings for the program are between 6:00am to 4:30pm[50]. This system also qualifies for designation of a large system (per APTA standards) as the system supports a fleet size of more than 200 vehicles.

Montgomery County Department of Transit provides service on 84 routes, inclusive of weekend, express and other shuttle services. The transit services are offered free to seniors' age 65 or older or disabled with a valid metro ID card and the disabled commuters' attendants between the hours of 9:30am to 3:00pm weekdays only[51]. This county's route system is fairly comparable to Westchester County's Bee-Line system. This is another system classified as a large system with the qualification of 200 or more vehicles in the fleet.

VIA Metropolitan Transit for San Antonio, TX also offers special off-peak fare for senior and commuters with limited mobility. These commuters can ride the system for $0.25 during the hours of 9am to 3pm on weekdays and free all day on weekends with the presentation of a valid VIA ID[52]. VIA is a large transit system, supported by a fleet or more than 200 vehicles.

5.4 Conclusions

The above was a brief study of almost all the transit properties that ever offered, or are offering a time based fare differential in any form within the US Bus Transit Systems. There might be some small systems that could not be traced due to lack of internet information.

There are other examples in Canada, Europe and other Asian cities that are not a part of this presentation. There is a mention of the similarities to the Bee-line system, wherever available, in terms of routes, fleet or demographics and geography.

In summary, the reasons for introducing the temporal based fare differential ranges from

- Equity concerns
- Motivation towards increasing ridership
- Motivation towards flattening the peak
- Initiatives to increase fare box revenues
- Measures for increase in revenues
- Mitigation of peak level of service parameters
- Make use of available off-peak capacity
- Making the ride more comfortable and safe for seniors and persons with limited mobility.

The prime reasons for discontinuing with the experiments ranged from:

- Non-attainment of defined goals
- Not able to sustain the comprehensive nature of variable pricing with implementation issues – most common being the adherence to changed times and fares.
- Unknown

The systems that have had or have successfully implemented programs are:

- Fairly large systems – with most of them being classified as large systems by APTA on the criterion of fleet size.
- Very well researched and documented. They regularly evaluate the system vis-à-vis important parameters eg. Elasticities, performance characteristics and passenger perception.
- Set realistic goals and planned for dealing with failures with extensive and well targeted marketing initiatives.
- Realized that all the goals are not always achieved.

The Cervero study calculated fare elasticities for a few agencies and are tabulated for quick reference:

Table 18: Price Elasticities for Various Transit Agencies

Agency	**Location**	**Elasticities**			
		Price			**Vehicle Mile**
		Peak	Off-Peak	Average	Average
Metro Regional Transit Authority	Akron, OH			btw -1.28 & +0.40	
LANTA	Allentown, PA	-0.85	-0.66		
B.C. Transit	Broome County, NY			-1.15	
Chittenden County Transit Authority	Burlington, VT			btw -1.12 & -0.37	btw 0.5 & 0.7
SORTA	Cincinnati, OH	-0.31	-0.69	-0.13	
Central Ohio Transit Authority	Columbus, OH			-0.94	
Regional Transit District	Denver, CO			-0.22	
Erie Metropolitan Transit Authority	Erie, PA			btw -0.5 to -0.9	
Orange County Transit District	Orange County, CA			declined from -0.31 in 1980 to -0.28 in 1981	
Utah Transit Authority	Salt Lake City, UT			-0.385	
Metropolitan Transit Corporation of King County	Seattle, WA			changed from -0.1 in 1979, -0.47 in 1980 and -0.55 in 1982	
DART	Wilmington, DE			changed from -0.47 FY82 to -1.28 FY83	
Massachusetts Bay Transit Authority	Boston, MA		btw -0.08 & -0.15		

It will also be prudent to mention here that a fare elasticity model was developed for Westchester County by Hartgen et al. in 1976 wherein the elasticity for the system was estimated at -0.57, quite high by average transit elasticity values.

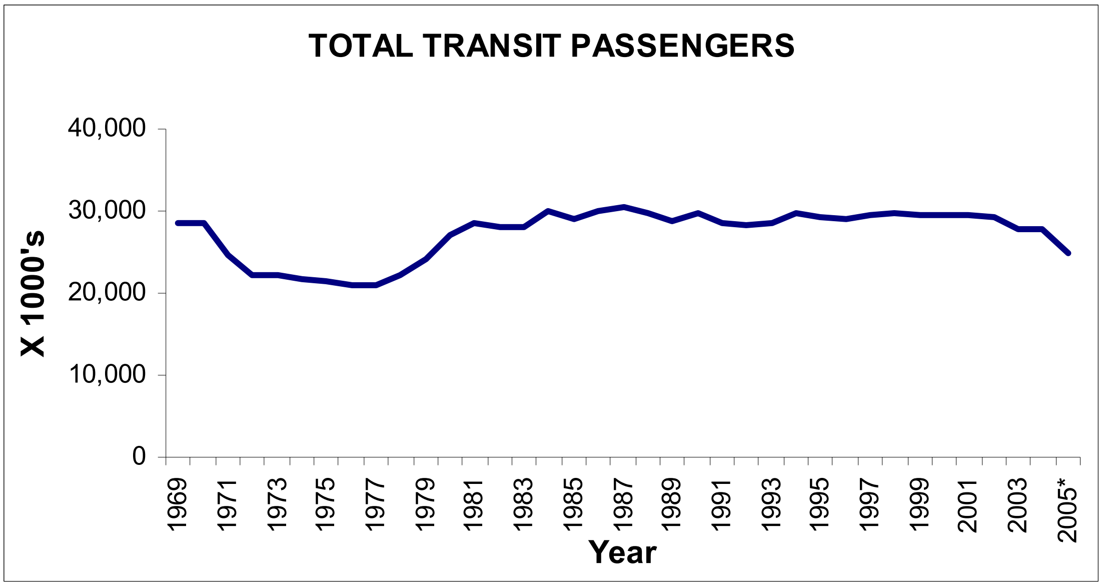
This would go to imply that Bee-Line system is quite elastic and sensitive to fare changes.

6. Fare Elasticity Study and Analysis of the Bee-Line System

6.1 Introduction

The ridership for the Bee-Line service has remained consistent throughout the period for which data was available except for the decade of the 70s'. Figure 2 illustrates the trend from 1969 through 2005.

Figure 2: Total Transit Passengers



* 2005 is not a typical year for Bee-Line transit, considering the facts of transit workers strike (March 3 – April 22, 2005) and fare free policies being in effect for a month (April 23 – May 31, 2005).

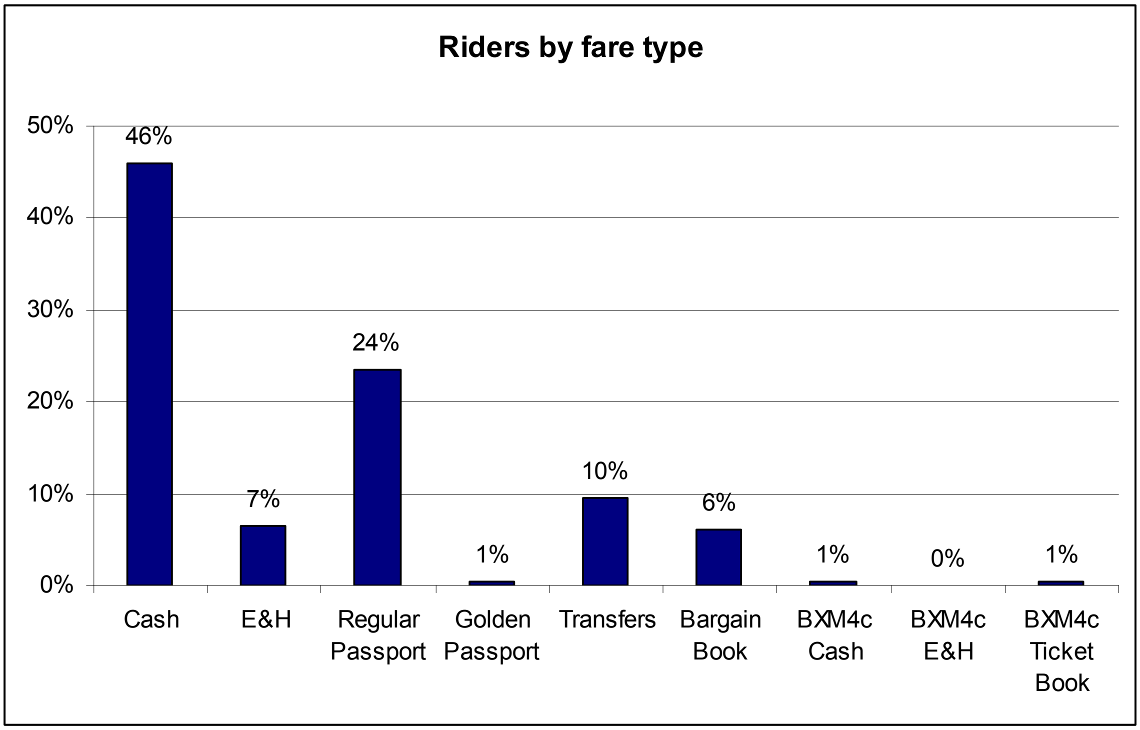
The seventies saw a decline in the ridership. Year 2005 is unique in ridership numbers. The year saw a transit strike followed by a fare free period aimed at getting the riders back on the system. The experiment was a success in terms of getting the riders that were lost due to the strike back on the buses. The fare free period, however, did not increase ridership to the extent that was predicted/ projected.

Hartgen et al., conducted a fare elasticity study for Westchester County bee-line system in the 1970s' wherein the elasticity was calculated using the least square regression of time series data. The elasticity for the system was -0.57.

There were only two fare structures in 1969 continuing through 1978, regular adult and E&H tickets. A transfer fee of a dime was initiated in 1978. Regular passport was incorporated in the fare hierarchy in 1979. Regular passport is a pass for multiple local rides for an adult commuter. Express service with its adult fare (BxM4c), E&H reduced fare (BxM4c E&H) and golden passport was introduced in 1985. In 1993 another variation in fare structure was applied, the ticket book. With 1995 the fare structure (as applicable by 2006) was complete with the initiation of the bargain book.

Figure 3 gives an idea of the percentage of riders for each fare type.

Figure 3: Riders by Fare Type



From figure 3 it can be inferred that the express E&H riders are not a statistically significant group. This in turn implies that there is only one category of E&H commuters, E&H cash.

Combining the results from Figure 2 & 3, E&H category riders would have contributed no more than approximately 7% to the total ridership along the years.

Hence, for the purposes of this modeling effort it is assumed that the E&H group will be approximately 7% of the total riders on Bee-line system.

Since 2005 had unique resident conditions and cannot be considered a typical year, we will drop it from the elasticity analysis.

Before proceeding with the model selection, it would be pertinent to list some of the underlying assumptions.

Assumptions for analysis:

1. The E&H patronage is about 7% of the total ridership for the system, as represented in Figure 1.
2. Similar percentage patronages are also assumed for the other categories while calculating the average fares for the elasticity analysis.
3. E&H category has been subjected to a sensitivity analysis, wherein the patronage is assumed to range between 1% and 9% of the total system ridership (the analysis is done in increments of 2%).

4. Furthermore, while defining the E&H peak and off-peak temporal ridership splits for the system, it is assumed that it equals the percentage split for total ridership.
5. All the 20 routes that have peak period split between 80% and 100% are assumed to be operative during peak periods only and are excluded while calculating the temporal split.
6. All the routes with peak period split between 50% and 80% are assumed to be catering mainly to peak and near peak demand, and are also excluded while calculating the temporal split.
7. The peak period for Bee-Line system is defined as being between 6:00AM to 8:30AM and 4:00PM to 7:00PM.
8. The temporal splits are also subjected to sensitivity analysis wherein the assumptions for the peak period split range from 25% to 45% (the analysis is done in increments of 5%).

6.2 Fare Elasticity Analysis

There are two categories of elasticity models prevalent in transit literature:

- Quasi-experimental models, and
- Time series analysis models

Quasi experimental models refer to short term elasticity models such as point elasticity, shrinkage ratio, mid-point elasticity and arc elasticity models.

The first two models assume an underlying linear relationship between price and quantity. We are not assuming a linear relationship as that is not the case.

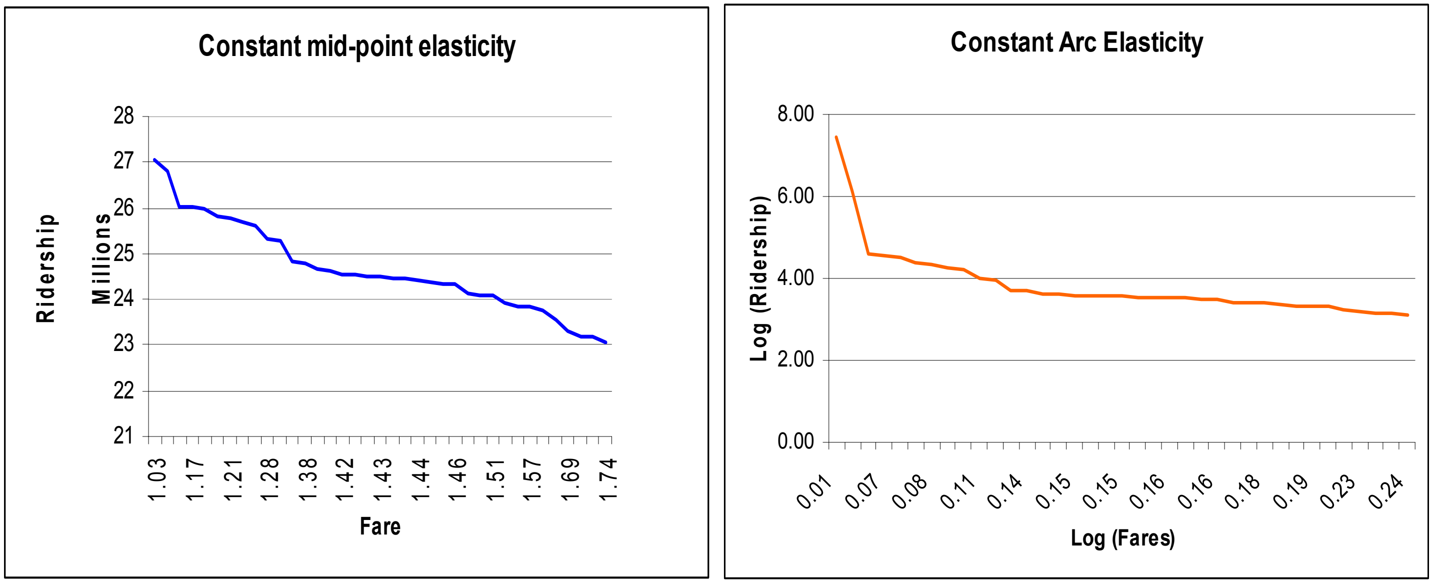
Also the independent and dependent variable are correlated (0.35 for systemwide ridership and 0.61 for E&H ridership). Also, it is to be noted that research has indicated a convex demand curve structure, which in itself will be a violation of the linearity assumption.

Hence, the models to consider will be mid-point elasticity model and arc elasticity or log-log elasticity model. Both the models assume a non-linear relationship between demand and price, which fits with our data structure.

Mid-point and arc elasticity models have a convex demand curve at constant elasticity values, but the shapes of these curves are a little different from each other as illustrated in Figure 4.

The other category of elasticity models are the time series analysis models wherein an analysis is performed on a times series dataset for a long period of time, usually five to ten years. The elasticity values are calculated using least square regression analysis in most cases. Other models such as behavioral logit and nested logit models have also been explored. The models analyze the entire database, and wherever there is no information available on fare changes, the real value change in fares is substituted and incorporated into the model. This usually leads to lower elasticity values.

Figure 4: Price Elasticity (Mid-point & Arc Elasticity)



In order to get a fair comparative measure for the elasticity values, the following three fare elasticity models were developed:

- Midpoint elasticity model
- Arc or log-log elasticity model
- Least square regression elasticity model

The model details and results as described in the following narrative.

<u>Midpoint elasticity model:</u>

Mathematically, a midpoint elasticity is formulated as

‘e = $[(R_2 - R_1)(F_2 + F_1)] / [(R_2 + R_1)(F_2 - F_1)]$

Where:

`e = Mid-point elasticity

R_1 = Total ridership for the current year.

R_2 = Total ridership for the succeeding year

F_1 = Average fares for the current year

F_2 = Average fares for the succeeding year

The mid-point elasticity values were calculated for each year from 1969 to 2004. They were then averaged over the years that had some kind of fare change. This included the years when a new fare category was established as well as when the fares were changed for existing categories. The average midpoint elasticity value for Bee-Line system is -0.34, and is within the range typical for transit commuters.

The midpoint elasticity for E&H commuters for the system was also calculated for the years 1969 to 2004 and was similarly averaged to be -0.28.

Since the underlying assumption for 7% E&H patronage was subject to change, a sensitivity analysis was performed in order to get a better picture of the changes. A similarly averaged value for mid-point elasticity for E&H patronage ranging from 1% to 9% of the total ridership is -0.30. This remains constant over all the incremental analysis (2% increments) between 1% and 9% of total ridership.

<u>Arc Elasticity model</u>:

Mathematically, arc elasticity (also referred to as log-log elasticity) is depicted by the following equation:

$E = (\log R_2 - \log R_1) / (\log F_2 - \log F_1)$

Where:

E = Arc Elasticity

Log R_1 = Logarithm of ridership for the current year, to the base of 10

Log R_2 = Logarithm of ridership for the succeeding year, to the base of 10.

Log F_1 = Logarithm of fares for the current year, to the base of 10

Log F_2 = Logarithm of fares for the succeeding year, to the base of 10

Arc elasticity was again calculated for years 1969 through 2004. The log-log fare elasticity for Westchester County Bee-Line transit was estimated by averaging over the years that had some kind of fare change, inclusive of changes in fares for existing categories as well as any change in the categories of fares offered to the commuters. The arc elasticity for Bee-Line system is -0.34.

Similar calculations were also conducted for the E&H commuter group with the average fare elasticity estimated at -0.28. The calculation and estimation of fare elasticities for E&H category emulated the pattern of system wide riders.

Again a sensitivity analysis on the E&H patronage revealed an estimated elasticity value of -0.30 consistently through the incremental values.

Least square regression elasticity model:

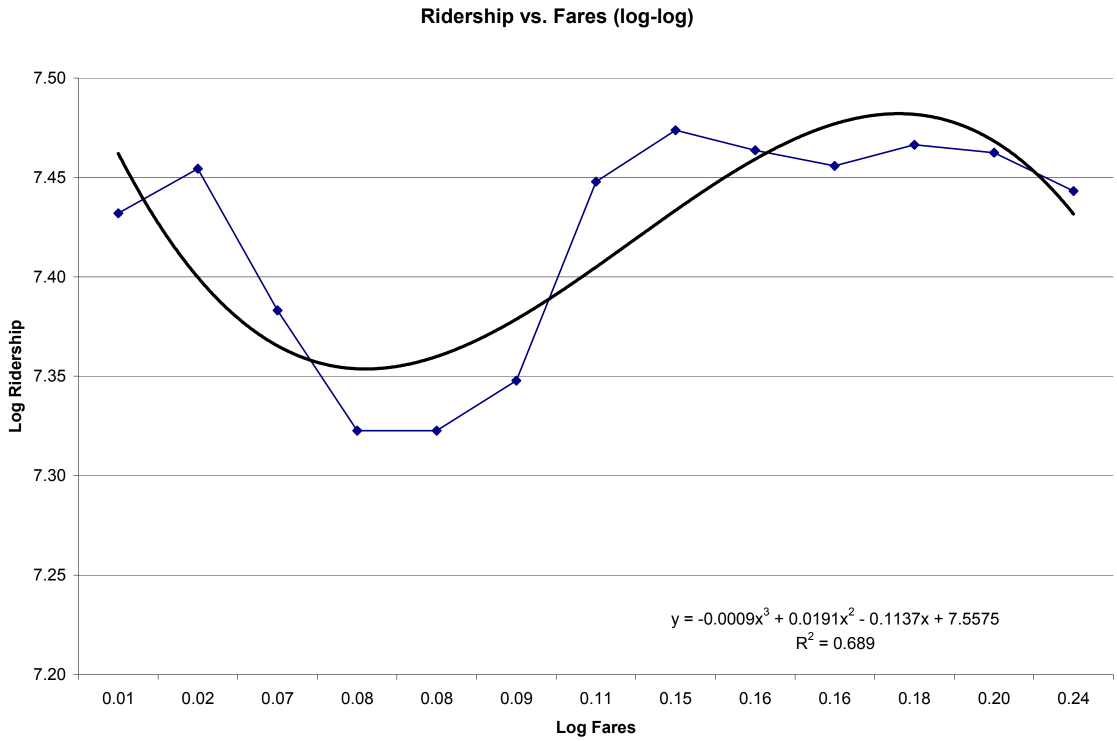
The time series approach includes the calculation of transit patronage as a function of real fares (after adjustment for changes in Consumer Price Index –CPI) and time trends.

As the transit ridership trends for Westchester County have remained fairly constant throughout available historical data, the time trends variable tends to 1. Also, the data is aggregated annually, which eliminates any seasonal effects for the model.

The above listed variables will have a bearing on the constant for the models.

The OLS model for total patronage demand for Bee-Line system is presented graphically in Figure 5.

Figure 5: Ridership trends w.r.t. Fares



The formulation of the OLS model for Bee-Line bus transit system demand is as presented

Log(R) = -0.0009 x Log(F)³ +0.0191 x Log(F)² -0.1137 x Log(F) +7.5575

Where:

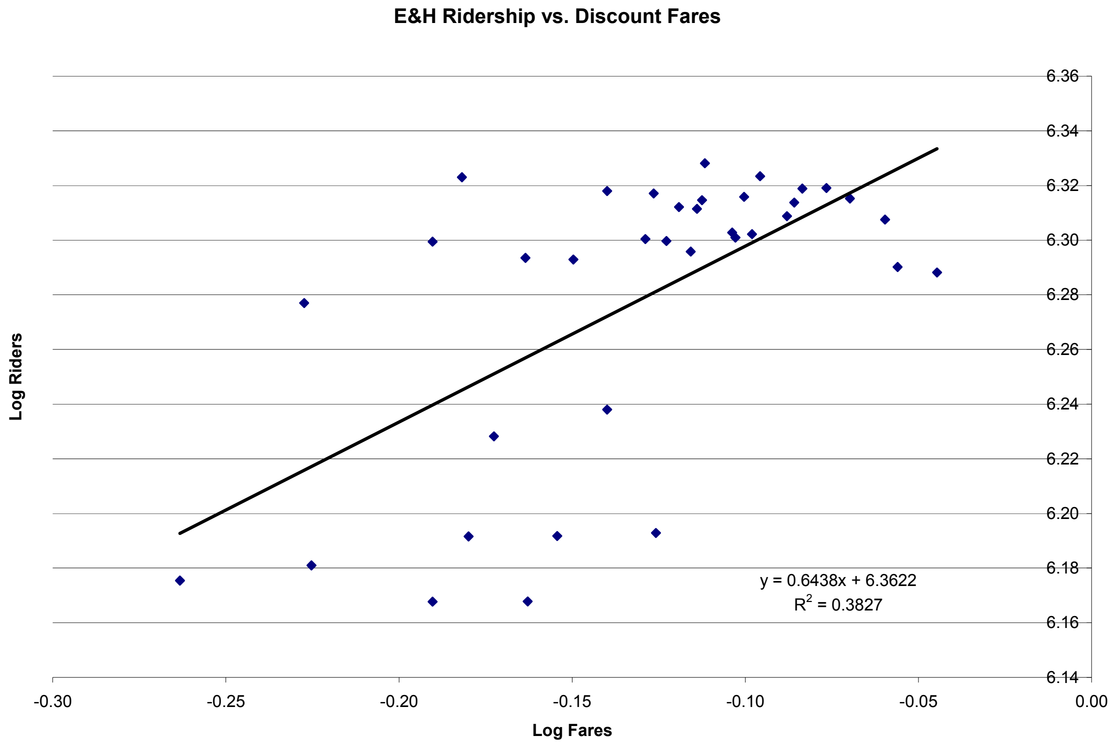
R = Total ridership on the Bee-line system

F = Average fares for the system weighted by the transit patronage by the respective fare categories.

The estimated elasticity for the system is -0.11, which is consistent with the long-term elasticity values for bus transit in New York City.[63] The value of R^2, that is a measure of fit, for the model is 0.69, implying a 69% goodness of fit.

The E&H patronage of Bee-Line system is also calculated and illustrated in Figure 6.

Figure 6: Reidership Trends w.r.t. Discount Fares



The model formulated in the figure is mathematically represented as:

Log (R) = 0.6438 x Log (F) +6.3622

Where:

R = E&H patronage for Bee-Line transit

F = Fare structure for Bee-Line E&H commuter category

The goodness of fit for the model is 0.38 or 38%. Since the model does not analyze the time trend for E&H population in the county due to unavailability of data, the model may propose erroneous results. This model has been formulated only for information purposes, and does not continue further in our report.

Temporal Transit Split:

For the purposes of estimating a temporal distribution, the data provided in the Urbitran Associates report detailing route characteristics was evaluated. The peak period on the Bee-Line system was defined to be from 6:00AM to 8:30AM and 4:00PM to 7:00PM. The peak period ridership percentage was calculated by averaging the percent riders over the routes that are operating all day (about 20 routes). The routes that exhibited abnormally high peak period riders, including the ones that are specifically peak period service routes, were excluded primarily because they would create a peak period bias. The peak period ridership was estimated at 41%. For the purposes of this report we will assume a 40% peak period ridership for the system.

On closer inspection, it was discovered that the range of peak period rideship varied from 18.75% for Route 9 to 48.59% for Route 7.

As the variation is vast, a sensitivity analysis was performed.

The fare elasticity values calculated for off-peak period were calculated to be between -0.28 and -0.30. Hence, the average off-peak fare elasticity for E&H commuter category is -0.29. The peak period fare elasticity was equally high at -0.28. This reflects on the perception that for E&H commuters, peak period is as good as off-peak period. The flexibility of travel vis-à-vis fares is fairly equal.

Hence, it might be a good practice to tap into the revenue base and a vision for provision of a better level of service to the E&H group during off-peak times. Off-peak times will be defined as between 9:30AM to 3:00PM. The hour between the morning peak and an hour before the afternoon peak are the near peak hours, and should also be avoided while doing the analysis for off-peak fares.

These are reflected in the numbers for peak and off-peak ridership split.

The alternative benefit analysis for each of the alternatives mentioned earlier in the report is presented in the succeeding section.

In conclusion, the elasticity values calculated for the Bee-Line transit system are summarized in Table 19.

Table 19: Transit Elasticity for Bee-Line System

	Mid-point	**Arc Elasticity**	**OLS**
Bee-Line System	-0.34	-0.34	-0.11
E&H	-0.28	-0.28	
E&H Peak	-0.28	-0.28	
E&H Off-peak	-0.29	-0.29	

The short term system elasticity is within transit averages, while the long term elasticity values are closer to the long term analysis for geographically related and transit compatible area of New York City.

E&H elasticity values are higher compared to transit averages, but there are not many studies that look into the elasticity of senior citizens or elderly and handicapped category of commuters.

7. Study of Alternative Fare Structures

7.1 Introduction

In conversation with city officials, it was determined that they would be looking forward to the revenue and benefit analysis of the three alternatives. The alternatives are listed in Table 20 and are also presented below for quick reference.

Table 20: List of Alternatives

SCENARIO	BASE FARE	OFF-PEAK FARE
No change Alternative	E&H discounted fare	E&H discounted fare
Alternative 1	E&H discounted fare	$ 0.50
Alternative 2	E&H discounted fare	$ 0.25
Alternative 3	E&H discounted fare	Free

The benefit of farebox revenue is underlined with the following assumptions:

1. The cost of operating the system for either of the alternatives is the same, hence does not contribute to the revenue changes.
2. The benefits of the system are studied and presented for the listed fare changes only. Any and all other changes, including service and fare changes that are not mentioned are also not considered to be contributing factors.
3. The analysis needs to be revisited once some form of temporal pricing is in effect to estimate the temporal elasticities for E&H commuter group. This is necessary as there is no such system in place now to base our estimation on quasi-experimental models. The ridership numbers presented are projected numbers using the elasticity from the models calibrated and validated in the preceding section.
4. As fare-free alternative will be difficult to project into ridership numbers, a penny fare alternative will be substituted for the same.
5. The revenue changes also do not take into account any outreach efforts that are being undertaken or will be undertaken as there is no documented evidence of ridership changes for Bee-Line system evolving from such efforts. These could be part of further research and modeling efforts.

7.2 Alternative Fare Structure Analysis

The mid-point elasticity model was promoted to project the ridership numbers through 2011. The fares for off-peak were changed as of 2008, keeping in view the current time frame.

All the fares are in terms of 2005 dollars, using the adjustment factor for Consumer Price Index (CPI) provided by the state of Oregon[64].

The following tables 1, 2, 3 and 4 illustrate the revenue changes due to the changes in ridership for the system.

All the ridership numbers are for E&H category of Bee-Line transit patrons.

No Change Alternative:

This alternative is equivalent to no-build where the analysis primarily reflects the background growth of the system, unchanged. There is no fare change and all the fares are in terms of 2005 dollars.

Table 21: Existing Revenue Calculations

E&H Revenue Calculations for Existing Conditions					
Year	**Fare Elasticity**	**Ridership**	**Ex. Fares**	**Ridership Ch.**	**Revenue Ch.**
2004		1,950,485	0.88		
2005	-0.28	1,969,518	0.85	19,034	$ 16,178.51
2006	-0.28	1,986,964	0.82	17,446	$ 14,369.20
2007	-0.28	1,998,734	0.81	11,770	$ 9,491.81
2008	-0.28	2,010,851	0.79	12,117	$ 9,563.24
2009	-0.28	2,023,298	0.77	12,447	$ 9,609.37
2010	-0.28	2,035,551	0.76	12,253	$ 9,257.92
2011	-0.28	2,048,116	0.74	12,565	$ 9,287.27
SUB-TOTAL					**$ 77,757.32**

The farebox revenue accounts for approximately $77,760 in terms of increase in ridership because of the fall in real fares.

Alternative 1:

This alternative analyzes a 50c off-peak fare while the peak period fares remain the same. The peak period fares remain the same as the existing fares while the off-peak period fares change from 85c as they are today to 50c.

The revenue changes attributed to fare changes only are of the order of $161,800. The E&H revenues for the system post a gain of $84,000 over a period of four years (2008, 2009, 2010, 2011). Table 22 presents the calculations.

Table 22: Revenue Calculations – Alternative 1

E&H Revenue Calculations - Alternative 1 (Peak and Off-peak 40 - 60 split)										
Year	**Peak elasticity**	**Peak Riders**	**Fares**	**Ridership Ch**	**Revenue Ch**	**Off-peak elasticity**	**Off-peak Riders**	**Fares**	**Ridership Ch**	**Revenue Ch**
2004		780,194	0.88				1,170,291	0.88		
2005	-0.28	787,807	0.85	7,613	$ 6,471.40	-0.29	1,182,121	0.85	11,830	$ 10,055.54
2006	-0.28	794,786	0.82	6,978	$ 5,747.68	-0.29	1,194,502	0.82	12,381	$ 10,152.59
2007	-0.28	799,494	0.81	4,708	$ 3,796.72	-0.29	1,198,760	0.81	4,258	$ 3,448.94
2008	-0.28	804,340	0.79	4,847	$ 3,825.30	-0.29	1,403,525	0.46	204,765	$ 95,062.81
2009	-0.28	809,319	0.77	4,979	$ 3,843.75	-0.29	1,412,524	0.45	8,999	$ 4,086.71
2010	-0.28	814,220	0.76	4,901	$ 3,703.17	-0.29	1,421,385	0.44	8,861	$ 3,938.11
2011	-0.28	819,246	0.74	5,026	$ 3,714.91	-0.29	1,430,473	0.43	9,088	$ 3,951.45
SUB-TOTAL					**$ 31,102.93**					**$130,696.15**
TOTAL										**$161,799.08**

Table 23: Revenue Calculations – Alternative 2

E&H Revenue Calculations - Alternative 2 (Peak and Off-peak 40 - 60 split)										
Year	**Peak elasticity**	**Peak Riders**	**Fares**	**Ridership Ch**	**Revenue Ch**	**Off-peak elasticity**	**Off-peak Riders**	**Fares**	**Ridership Ch**	**Revenue Ch**
2004		780,194	0.88				1,170,291	0.88		
2005	-0.28	787,807	0.85	7,613	$ 6,471.40	-0.29	1,182,121	0.85	11,830	$ 10,055.54
2006	-0.28	794,786	0.82	6,978	$ 5,747.68	-0.29	1,194,502	0.82	12,381	$ 10,152.59
2007	-0.28	799,494	0.81	4,708	$ 3,796.72	-0.29	1,198,760	0.81	4,258	$ 3,448.94
2008	-0.28	804,340	0.79	4,847	$ 3,825.30	-0.29	1,658,182	0.23	459,422	$106,643.98
2009	-0.28	809,319	0.77	4,979	$ 3,843.75	-0.29	1,668,814	0.23	10,632	$ 2,414.11
2010	-0.28	814,220	0.76	4,901	$ 3,703.17	-0.29	1,679,282	0.22	10,468	$ 2,326.32
2011	-0.28	819,246	0.74	5,026	$ 3,714.91	-0.29	1,690,020	0.22	10,737	$ 2,334.20
SUB-TOTAL					**$ 31,102.93**					**$137,375.68**
TOTAL										**$168,478.61**

Table 24: Revenue Calculations – Alternative 3

E&H Revenue Calculations - Alternative 3 (Peak and Off-peak 40 - 60 split)										
Year	**Peak elasticity**	**Peak Riders**	**Fares**	**Ridership Ch**	**Revenue Ch**	**Off-peak elasticity**	**Off-peak Riders**	**Fares**	**Ridership Ch**	**Revenue Ch**
2004		780,194	0.88				1,170,291	0.88		
2005	-0.28	787,807	0.85	7,613	$ 6,471.40	-0.29	1,182,121	0.85	11,830	$ 10,055.54
2006	-0.28	794,786	0.82	6,978	$ 5,747.68	-0.29	1,194,502	0.82	12,381	$ 10,152.59
2007	-0.28	799,494	0.81	4,708	$ 3,796.72	-0.29	1,198,760	0.81	4,258	$ 3,448.94
2008	-0.28	804,340	0.79	4,847	$ 3,825.30	-0.29	2,147,053	0.01	948,293	$ 8,804.95
2009	-0.28	809,319	0.77	4,979	$ 3,843.75	-0.29	2,160,819	0.01	13,766	$ 125.03
2010	-0.28	814,220	0.76	4,901	$ 3,703.17	-0.29	2,174,374	0.01	13,555	$ 120.49
2011	-0.28	819,246	0.74	5,026	$ 3,714.91	-0.29	2,188,277	0.01	13,903	$ 120.90
SUB-TOTAL					**$ 31,102.93**					**$ 32,828.44**
TOTAL										**$ 63,931.37**

Alternative 2:

Alternative 2 analyzes the effect of 25c fare for off-peak E&H patrons. The E&H revenues are estimated at $168,500. The implementation of this fare structure would benefit the exchequer to the tune of $90,700 over the benchmark of no change alternative, all other variables kept constant. Table 23 shows the calculations for Alternative 2.

Alternative 3:

Alternative 3 proposes a fare free off-peak ride for all E&H patrons. Though this looks like being the most lucrative proposal, this is the only one that estimates lose to the farebox revenue. Although the year following the fare change registers a jump in ridership numbers, the ensuing drop in off-peak riders is substantial as well. The jump is not sustained. The analysis could predict very faulty numbers for this particular alternative, as we are analyzing with the difference in fares for successive years, which will give pretty low numbers in both the numerator and denominator. Further analysis after the implementation of a temporal pricing program might reveal a different off-peak elasticity, leading to vary different results.

On the flip side, these results can be interpreted similarly by reviewing the fare free experiments in Trenton, NJ. The fare free off-peak period travel led to tremendous loses in farebox revenues because of the increase in crime rates, indiscipline on the fleet considered to be a direct cause of no fares.

From another study in Denver, there are similar results. The lack of discipline leads to decrease in riders during off-peak period even though it might just be perceptive reaction than any real concern.

This concern might be reflected in the analysis, although not intentionally, resulting in loses to the exchequer of about $13,800.

The number reflects an estimated 18% revenue lose from the base alternative.

In summary, the most lucrative fare change will be Alternative 2 with a quarter as fare for off-peak period and 85c fare for peak period.

The decision is left to the department of transportation at Westchester County, but the recommendation stands for implementation of Alternative 2.

All the analysis is riddled with assumptions, and might not be a true representative of the inherent transit conditions on Bee-Line transit. Hence, these are all gross estimations of the fact, and are solely for the purposes of providing study options and analysis models for the department. Table 24 presents the calculation results for Alternative 3.

8. Conclusion

The exhaustive research is an initiation into the conceptual arena of transit demand modeling. The extensive database needs to be studied in more detail in order to replicate the dynamic conditions on Bee-Line bus routes.

Further research is already ongoing towards developing a direct ridership model for the System, following in footsteps of Robert Cervero. He has recently (2005) developed a direct ridership model for BART extension, the T-BART, into the suburbs, working with the traditional four step transportation model, while incorporating other variables in a direct causal relationship with transit demand.

Further modeling efforts will concentrate on developing nested OLS/logit models in order to better capture the dynamics of demand on Bee-Line system, by incorporating both demand and supply, both as dependent and independent variables. The model hopes to illustrate the interactions between demand and supply in a bus transit property. Micro level GIS analysis is being conducted and will feed into the proposed model.

Concluding this phase of research, however, it needs to be reiterated that the analysis was subject to numerous assumptions that are not hard to replace with actual data if and when that is made available.

This is a dynamic report and the databases will be provided as soft copies for the purposes of independent analysis by the department officials.

8.1 Highlights/Summary

Westchester County's Bee-Line transit is heavily used with fare elasticity value of -0.28 (short term) and -0.114 (long term). The values reflect closely the elasticity for the neighboring/collaborative New York City. Westchester County's geographical location close to NYC puts the Bee-Line system in direct relationship with NYC Transit and MTA systems. The decision to honor Metro-cards on Bee-Line system in the recent past (2006) reflects the inter-relationship.

E&H riders are an integral part of the systems patronage. With the baby boomers aging, the concerns for their transportation and mobility have taken center stage in transportation planning and research. With this goal in mind, the study was undertaken at the behest of Westchester County DOT.

The report presents some interesting revelations. Although it was assumed that the peak period elasticity is about half to a third of its off-peak counterpart, it was rightfully predicted to be almost equal for the E&H riders. This hinges on the relationship of demand with trip purpose. The work trips lower the peak period elasticity numbers, because of the inflexibility of the workers. However, the only inflexible trips suitably considered for E&H (considering the group consists primarily of retired seniors) will be the medical trips.

The analysis on the basis of trip purpose for E&H commuters will warrant another more rigorous study.

The purpose of the study, in terms of questions formulated in the transit pricing literature review section have been considered and answered to the best of the ability with the limitations on data and various non-related sources of the datasets.

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