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The Fairfax County Connector Bus System: Measuring the Impact of Subsidized Fares on Ridership

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1. Introduction

1.1 Purpose of the Study

This study hypothesizes that low-income, automobile-based commuters within the service areas of the Fairfax Connector bus system can be persuaded to use the Fairfax Connector county bus system, as opposed to a single occupancy vehicle (SOV), if the cost of their Connector fare is partially subsidized. This increase in the relative affordability of public transportation will enable targeted low-income commuters to take advantage of new, higher-paying job opportunities that may currently exist beyond their affordable commuting distance. Although not explicitly modeled, we surmise that increased utilization of the Fairfax Connector will also provide the added benefit of removing additional automobile traffic from the county's crowded roads and highways, thereby decreasing automotive traffic and providing benefits to commuters and employers.

This study proposes two options for increasing Fairfax Connector ridership of the target citizen group. In Proposal A, a debit card would be provided to low-income commuters, providing a fixed dollar amount of $50.00 each month for use on the Fairfax Connector. In Proposal B, identification cards similar to the Metro ID (issued by the Washington Metropolitan Area Transit Authority to elderly and handicapped riders) would be issued to low-income commuters, enabling the bearer to purchase a Fairfax Connector bus fare at 50% of the normal rate. A comparison of the models for each proposal, utilizing microeconomic theory, will determine which proposal provides the highest probability of increasing Fairfax Connector ridership while incurring the lowest cost for Fairfax County taxpayers.

1.2 The Low-Income Population of Fairfax County

Fairfax County has long been recognized as one of the most affluent areas in the nation. Its high median household income in 2004 ($88,133) placed it at the top of the US Census Bureau's American Community Survey - nearly twice the national average of $44,389[1]. This disparity can be explained by the large number of high-technology jobs in areas such as Tysons Corner and the Dulles Technology Corridor, combined with high-level government positions in Washington DC.

However, as with any large metropolitan area, Fairfax County has its share of households facing economic difficulty. According to Fairfax County, 4.4% of county residents were at or below the poverty line in 2004[2]—defined as an income of $15,067 for a family of three[3]. However, due to the high cost of living in Fairfax County, an additional concern for county officials is the percentage of individuals existing above the poverty line but at a low-level of income. An examination of the county demographics reveals that 8.3% of households earned under $25,000 in 2004—a value that is less than one-third of the county median[4]. Based upon this measure and county population figures, it can be estimated that over 30,000 households in Fairfax County would be classified as low-income or impoverished.

It must be noted that the low-income and poverty-stricken residents are not evenly distributed throughout the geographic area of the county. Two low-income concentrations exist along the periphery of the county: at the Prince William County border on the western side and in Herndon along the Loudoun County border on the northern side. By far, the largest concentration of low-income and poverty stricken residents in Fairfax County live east of I-95, just south of the city of Alexandria along Route 1—referred to as the Route 1 Corridor[5]. According to data compiled by the National Capital Region Transportation Planning Board

(NCRTB) from the 2000 census, 24% of residents in the Route 1 Corridor existed below the poverty line[6].

In contrast, further analysis by the NCRTB reveals that job growth on the western side of the Metropolitan region (defined as west of I-95) outpaced growth on the eastern side by an astonishing twenty-to-one ratio during the period 1990-2000[7]. Although this trend will likely slow in the period 2002-2030, the NCRTB still forecasts job growth to be 26% percent greater in the west than the east[8]. Fairfax County planners face an ongoing cycle in which the majority of job growth will occur a significant distance from the population that could most benefit.

1.3 Traffic Congestion in Fairfax County

As one of the key urban areas in the United States, traffic congestion has long been an issue for residents, businesses, and local government officials in the Washington D.C. area. According to a recent survey by the Texas Transportation Institution, the Washington D.C. metropolitan area has the third worst traffic in the United States—with the average traveler spending 69 hours per year stuck in traffic delays[9]. These lost hours lead to increased frustration for area commuters, decreased productivity for area employers, and are expressed as voter dissatisfaction at election time.

Fairfax County, with over one million residents, is currently the most populated county in the Commonwealth of Virginia, and accounts for approximately 50% of the total population of the Northern Virginia region[10]. Its 395 square miles are currently home to over 700,000 registered automobiles and 800,000 registered drivers[11]. Fairfax County's traffic problems are emblematic of those experienced throughout the region. A recent survey of 1,820 county residents by *Fairfax Tomorrow* found that half of the county residents surveyed listed traffic, transportation, roads, and mass transit as the most important issues facing the county. In the same survey, 58% of respondents described traffic congestion as "a major problem;" while a further 21% labeled the current situation as "a crisis"[12]. The potential scope of this problem will only increase in coming decades: population predictions by the Metropolitan Washington Council of Governments show that Fairfax County will exceed 1.1 million residents in 2010, and will approach 1.2 million by 2020—with a corresponding increase in automobiles and drivers.[13]

1.4 The Fairfax County Connector

Local government officials, recognizing Fairfax County's rapid population expansion, established a county bus service in 1985. Originally designed to bring commuters in the southern part of the county to the Huntington Metrorail station, the Fairfax Connector has since added local lines that span the majority of the county, as well as express service into Crystal City and the Pentagon. An innovative "park-and-ride" system integrates the Connector with the DC Metrorail system, allowing commuters to "park" their cars in commuter lots along the Dulles Toll Road and "ride" the Connector for free to various Metrorail stations. The Fairfax Connector offers convenient routes to many residential destinations, shopping centers, and business developments within the County. Its fares make it one of the least expensive modes of personal transportation available, particularly when compared to the costs of purchasing and operating an automobile.

In 2005, the Fairfax Connector utilized a fleet of 174 vehicles and two bus operations centers, which are provided and owned by the County.[14] The majority of Connector vehicles are conventional 40-foot buses, augmented by smaller buses and vans; capacity for each vehicle varies between 29 and 55 passengers.[15] The Connector services 56 routes; 32 routes operate in the Reston-Herndon Division (including Fairfax, Herndon, Reston, and Tysons Corner), and 24 operate in the Huntington Division (Springfield, Fort Belvoir, and the Route 1 corridor).[16] In fiscal year 2005, the Fairfax Connector transported 8,474,143 passengers, an increase of 6% over the previous year.[17]

Connector fares vary based on the rider and the route taken as shown in Table 1 below. For a non-elderly, adult rider, all routes defined as local are $1.00 per trip, with designated express routes priced at $3.00. Disabled riders and elderly riders pay $0.50 for local routes and $1.00 for express routes, and children under the age of five ride free when accompanied by an adult. In addition, significant discounts are available for those who transfer from the Connector to Metrorail, while fares are free for a transfer from Virginia Rail Express (VRE) to the Connector.[18]

Fairfax Connector Bus Fares

Cash Fares	Cost
All Local Routes (except express routes below)	$1.00
Express Routes 380, 595, & 597	$3.00
Cash Fares With Rail-to-Bus Transfer	
All Local Routes (except express routes below)	$0.35
Express Routes 380, 595 & 597	$2.10
Senior-Disabled Cash Fares	
All Local Routes (except express routes below)	$0.50
Express Routes 380, 595 & 597	$1.00
With Rail-to-Bus Transfer on All Routes	FREE
MetroAccess Customer Fares	
All Routes for MetroAccess ID Card Holders and 1 Companion	FREE
Children's Fares	
Up to 2 Children 4 Years of Age and Under With Each Adult Paying Full Fare	FREE
Children Age 5 and Over	Adult Fare

Table 1 - Fairfax Connector Fares
(Source: Fairfax Connector webpage, http://www.fairfaxcounty.gov/connector/fare.html)

Based on financial statements published by Fairfax County, the total Connector operating funds for fiscal year 2005 were $30,208,289.[19] A total of $5,439,185 was reclaimed by Connector via fares - $4,554,929 (15%) from direct fare box revenues and $561,776 (2%) through reimbursement by the Washington Metropolitan Area Transit Authority (WMATA) for its tokens accepted as Connector fare. In addition, $322,480 (1%) was generated through sales of billboard advertisements placed on Connector buses.[20] $275,000 (1%) was received through a revenue sharing arrangement with Reston's Plaza America shopping center. $2,397,966 (8%) came from a grant from the Northern Virginia Transportation Commission (NVTC)—a multi-jurisdictional organization that allocates funds from the federal, state, and local governments in order to facilitate the planning and development of a transportation system for Northern Virginia.[21] $7,450,000 (25%) came through reimbursement from the state, as well as a $294,139 (1%) grant from the governor to alleviate county traffic. By far, the largest share of funding, $14,351,999 (47%), came from the Fairfax County taxpayers themselves. A summary of the sources of operating funds for the Fairfax Connector in 2005 are shown in Figure 1 below.

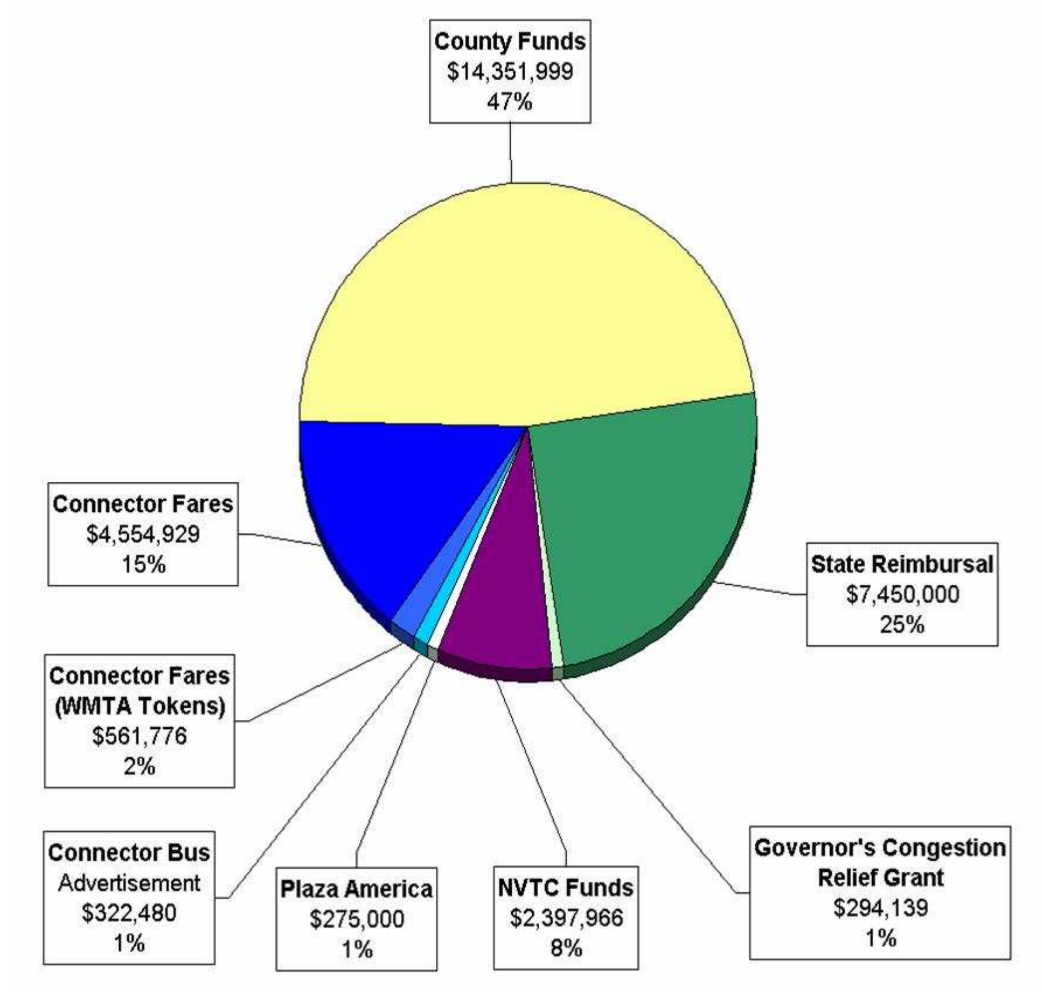

Figure 1 - Fairfax Connector Operating Funds by Source

(Source: Fairfax County Transit Systems)

2. Description of Economic Models

2.1 Public Transportation

The proposals set forth in this paper are centered on the concepts of a monopolistic market. In general, a monopoly occurs when one firm is the sole supplier to a market.[22] Since the Fairfax Connector is the sole public transportation supplier for specific routes in Fairfax

County, the Fairfax Connector ultimately is a monopolistic firm for specific routes in Fairfax County. Figure 2 below illustrates an economic model of a generic monopoly.

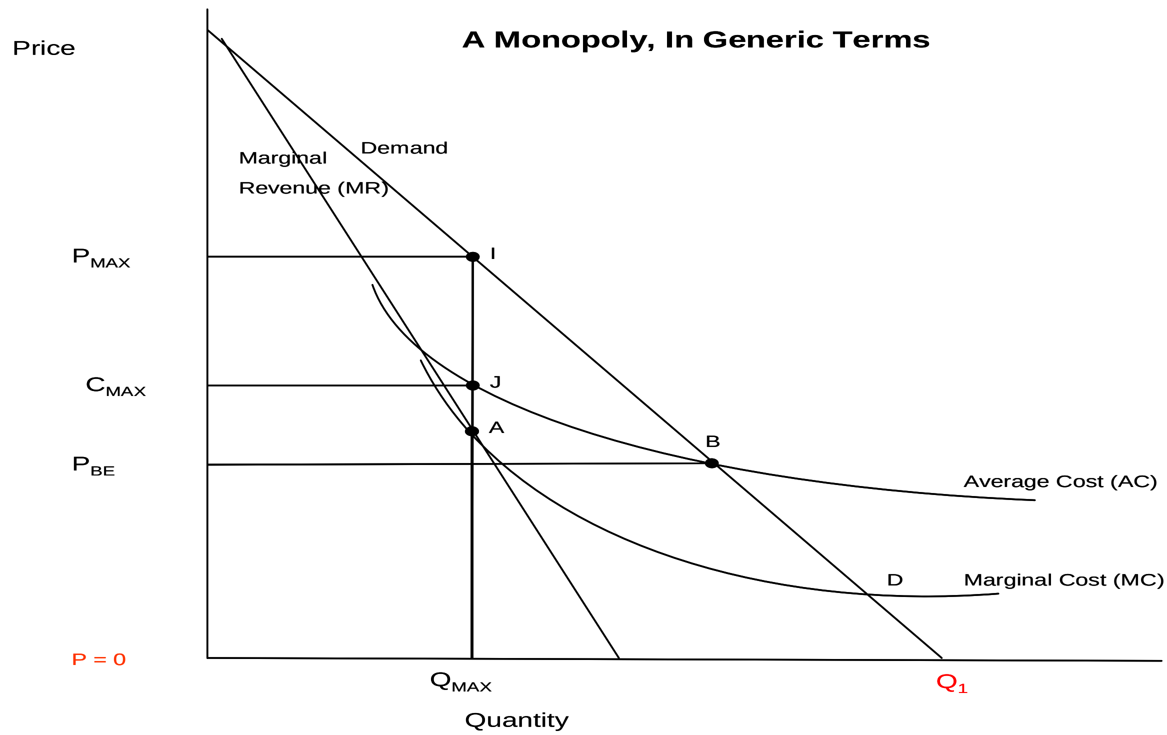

Figure 2 - Generic Monopoly Model

Since a monopolistic firm is the single supplier of a market, it can operate in many ways that a perfectly competitive firm may not, including in reference to prices. While perfectly competitive firms must operate where P = MC in order to obtain a share of the market, a monopoly can set its own price for a good and still be able to sell that good. To maximize profits, monopolistic firms produce at a quantity where MR = MC (point A), shown in Figure 2, at Q_{MAX}. In order to maximize profits, a monopoly will, therefore, charge a price of P_{MAX}, which generates revenues equal to the area denoted by $0P_{MAX}IQ_{MAX}$ and profits equal to the area $C_{MAX}P_{MAX}IJ$.[23] For a monopolistic firm to continue operating in the long run, it must be able to charge a price that is greater than average cost (AC)—the break even price shown in

Figure 1 as P_{BE}. Thus, in order to maximize profits, monopolistic firms will produce at a point where P > AC and, by extension, where P > MC.

As a result of the market power that corresponds with a monopolistic firm, monopolies do not only have the ability to set a price but to price discriminate, a process that occurs when a firm charges different prices to different groups of consumers.[24] We acknowledge that, due to the pricing structures discussed in section 1.3, the Fairfax Connector currently conducts price discrimination towards the elderly, the disabled, and children less than 5 years of age, as the Fairfax Connector charges fares to these sectors of the Connector market that differ from the regular $1.00 local fare and $3.00 express fare. To maintain a similar "spirit" to the current price structures of the Fairfax Connector, for the proposals discussed in this paper, the Fairfax Connector will continue to price discriminate between low-income consumers and all other consumers, since low-income consumers are being charged a lower fare than all other Fairfax Connector consumers.

An additional advantage of a monopolistic firm is the ability to determine what quantity of goods to produce. A monopoly firm produces at quantity of Q_{MAX} in order to maximize profits, ultimately producing less than a firm would in a perfectly competitive market. Upon looking at consumer surplus (CS) (the difference in the amount a consumer is willing to pay and what s/he actually pays as depicted by the demand curve), when profits are maximized in a monopolistic market, consumer surplus is described as the area above the price and below the demand curve, in this case, the area above P_{MAX}I and below the demand curve.[25] When a monopoly market exists, not only is consumer surplus reduced from the CS in a competitive market, but a dead weight loss (DWL) exists as well. Therefore, the net efficiency in a monopolistic model is not Pareto Optimal, as society as a whole would increase social welfare and efficiency by making P=MC, a phenomenon that occurs in a perfectly competitive market, and where efficiency is ultimately maximized. In this respect, while the Fairfax Connector ultimately has power in determining the quantity of buses and capacity of riders over the long term, its actions ultimately impact overall social welfare, which will be discussed in further detail in section 3.

Aspects of monopolies discussed above are significant to understanding the Fairfax Connector's existing model of operation, as well as the proposals discussed within this paper. Therefore, the models discussed in this paper will consist primarily of monopolistic models and the ideals discussed in this section.

2.2 Ridership Preferences

The increase in Fairfax Connector ridership as a result of a decrease in fare can be estimated utilizing the microeconomic concept of price elasticity. Price elasticity is defined as "...the percentage change in consumption of a good caused by a one-percent change in its price..."[26] Many sources are available that attempt to capture the effect of bus fare price elasticity on ridership. However, no single measure can be generalized across all situations and all cities.

The American Public Transportation Association (ATPA) estimates that the price elasticity in American cities with populations less than 1,000,000 during peak commuter hours is -0.27.[27] Although this estimate is widely accepted by transportation planners across the country, it only addresses the effects of price elasticity over the short-term. An article published in the Journal of Transport Economics estimates that price elasticity for buses internationally is -0.28 in the short-term, but increases to -0.55 in the long-term.[28] Since the short-term values between the two studies closely match, by extension, the short-term price elasticity of -0.28 will be utilized as the price elasticity for the Fairfax Connector throughout this paper. The models included in this paper illustrate short-run cost curves and also utilize short-run empirical information, such as annual revenues, annual total costs, and the quantity of passengers. Therefore, we believe that the short-run price elasticity of demand will be more consistent than the long run price elasticity of demand, with other information that we have utilized. While fare prices affect rider consumption of fares, the income of consumers matters as well. It has been noted that past studies have shown that consumer use of public transportation tends to decrease with an increase in income. For this reason, public transportation is seen as an inferior good.[29]

According to a study conducted by John Kain and Zvi Liu, the cross price elasticity of demand for regional employment as a factor of transit ridership is 0.25. This means that a 1% increase in employment will increase transit ridership by 0.25%. The cross price elasticity of demand for regional employment will be discussed further in reference to the proposals in Section 3.

2.3 Equity

By looking at how transportation dollars are spent within a tax district, one can draw conclusions about which groups get the most attention and therefore the most spending. Typical county transportation spending programs do not benefit all populations equally and, in this respect, Fairfax County is on par with the national averages. In the past 20 years, approximately 80 percent of all monies earmarked for surface transportation have been spent on new roads and existing road improvements, and about 20 percent on mass transit projects.[30] Furthermore, most transit systems tend to consider low-income, elderly, and immigrant populations as the "base" of ridership and focus advertising and pricing incentives on wealthier drivers in order to attract them away from their cars. Also, future investments in non-road transportation systems tend to focus on expensive commuter rail or bus lines that serve affluent neighborhoods and other riders that have a choice of transportation modes.[31]

Building a new highway or adding extra lanes to the Beltway provides virtually no benefit to a family that does not own a car. However, increased access to public transportation via reduced fares and increased routes directly affects these families. Fairfax and neighboring counties have seen rapid and significant changes in home values, employment opportunities, average income, and highway traffic. Poor, elderly, and immigrant county residents have been directly impacted by these changes and cannot adapt as fast as others.

Many states limit the use of gas taxes to highway construction and repair. Some states, including Virginia, use gas taxes to pay for other forms of transportation. A Brookings Institution Study in 2003 found that Virginia spent 80.7% of gas taxes on state-administered highways, 14.8% on local roads and streets, 4.3% on mass transit, and 0.2% on general fund and non-highway uses in the years 1998-2001.[32] The low amount of gas tax revenue spent on mass transit makes it difficult to compete for matching federal transportation grants and funding that would benefit mass transit riders. However, as discussed above, Fairfax County's annual budgets show that only small numbers of federal grants are applied for to support mass transit needs and that the bulk of external funding comes from state grants.

3. Description of Proposals

In several respects, the proposals discussed in this paper are modeled similar to the Bay Area Rapid Transit (BART) District, which has a public transportation system that is "subsidized by both federal grants and funds earmarked from local sales and property taxes; the rest of its costs must be covered by charging passengers fares, a break-even constraint."[33] Thus, due to the nature of a monopoly and the similarities between BART and the Fairfax Connector, the proposals and models studied in this paper will be modeled similar to Friedman's discussion of BART.

As with many situations, change results in additional costs stemming from the costs to change from the status quo. Should a change require new machines and new labor, such changes yield a change in the fixed cost of capital, and a change in variable costs (most closely linked to changes in the quantity of labor demanded and labor demand itself for changes in variable costs). For each of these proposals, an issuance of a photo ID or a debit card will yield administrative changes. Since the administrative costs of issuing either a photo ID or a debit card are likely similar in nature, a comparison of the costs of implementation for each proposal discussed would be negligible. Thus, we will focus our study on the increase in the amount of low-income persons that can attain employment through the use of either proposal discussed in this paper.

3.1 The Existing Monopolistic Model of the Fairfax Connector

Since many areas within Fairfax County are serviced by only one bus transportation service, the Fairfax Connector ultimately is characterized by monopolistic behavior in most instances. Therefore, the existing pricing model can be demonstrated using a monopolistic model as shown below.

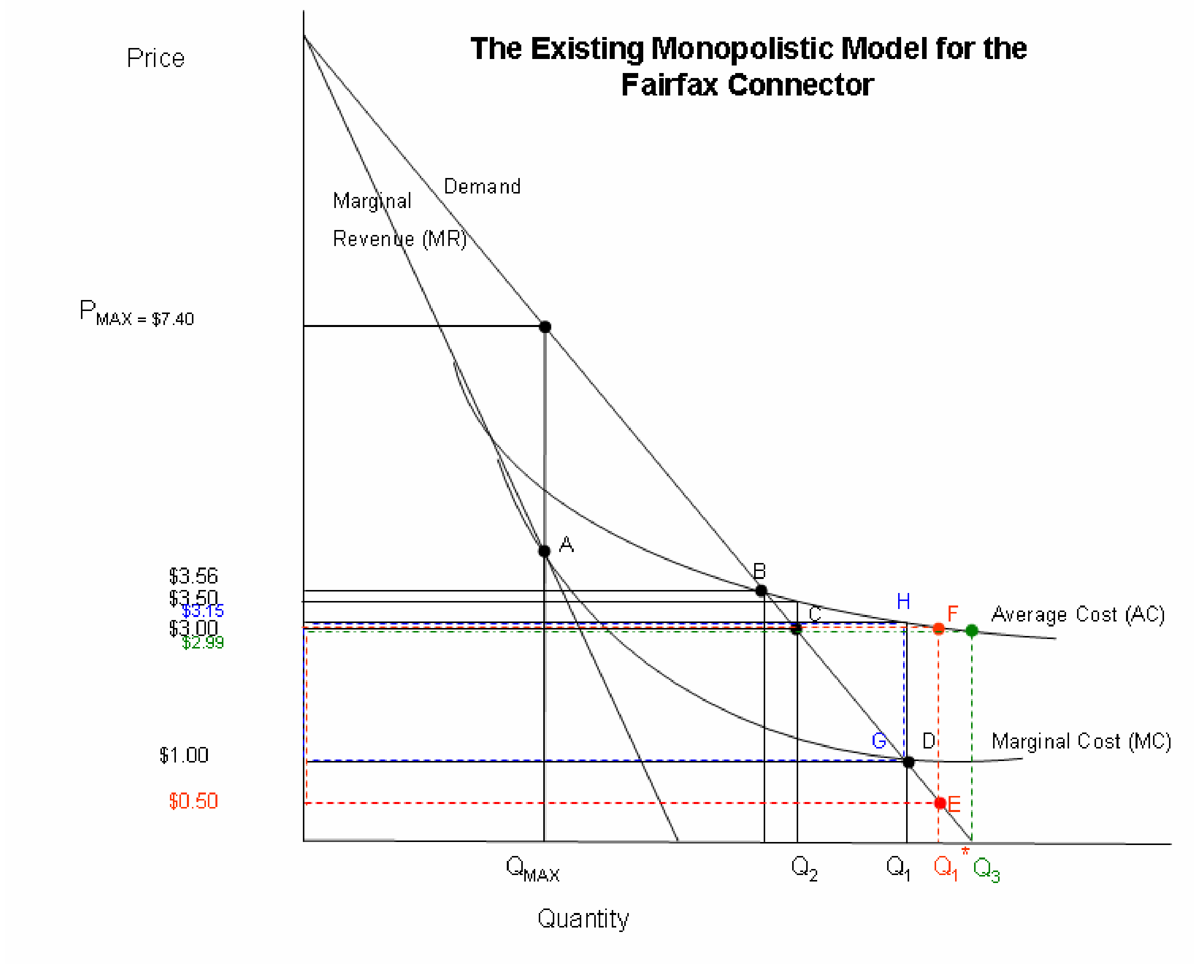

Figure 3 The Existing Model of the Fairfax Connector

According to the model, the Marginal Revenue (MR) curve intersects the Marginal Cost (MC) curve at point A. As described within section 2.1, because point A is where MR = MC, point A becomes the profit maximizing point for the Fairfax Connector. In order to maximize Fairfax Connector's profits, the Fairfax Connector should price its bus fares at P_{MAX}, where point A's corresponding quantity of Q_{MAX} determines the appropriate profit maximizing point where Q and P meet on the demand curve, which is at P_{MAX}. However, selling at P_{MAX} will only generate a Q_{MAX} amount of quantity demanded, due to a high price that approximately equals to $7.40. If, however, the Fairfax Connector chooses to operate at point B, profits will not be maximized, but the bus system would operate at the break even point, for reasons discussed in section 2.1. In other words, at point B, where the demand curve intersects the average cost curve, the profits [total revenue – total cost; or quantity demanded*(selling price – average cost)] will equal to zero. As mentioned in the previous section, during the fiscal year 2005, Fairfax Connector transported 8,474,143 passengers.[35] In order to calculate the average cost (Total cost/quantity), 8,474,143 is taken as the quantity, while the total costs, for the same period, which amounted at $30,208,289 is considered as the total cost. Hence, the average cost for the existing model is approximately $3.56. A further explanation of the calculations for average cost can be found in Section 6, the Appendix.

Based on the pricing structure of the Fairfax Connector, for a non-elderly adult rider, a $1.00 fare per trip is charged on all routes defined as local, while designated express routes are charged at $3.00. A $1.00 fare will generate a demand equal to Q_1. The total revenue earned through $1.00 fares will be equal to the rectangle with an area of $1.00*$Q_1$. However, the cost of supplying transportation services at a $1.00 fare price is much higher than the selling price; approximately the cost per one dollar-ride will be $3.15 (point H on the AC curve), and therefore, net loss per rider will be equal to $2.15*$Q_1$. A further explanation of the calculations for the cost per one dollar ride can also be found in Section 6, the Appendix.

Express routes priced at $3.00 per passenger will generate Q_2 amount of demand. Total revenue at this fare price will be equivalent to the rectangle with an area of $3.00*$Q_2$. Total cost on the other hand will be $3.50*$Q_2$, in which $3.50 is being spent on each passenger (an explanation of calculations and derivation of $3.50 can be found in the Appendix). Even though an express fare is priced at a higher level than a regular $1.00 fare, it still generates a loss equal to the area of ($3.50-$3.00)* $Q_2 = 0.5*Q_2$ as depicted in the above figure.

Fairfax Connector segments its targeted market by providing different fare rates to some customers. Specifically, as described in Section 2.1, the Fairfax Connector performs price discrimination by providing disabled and elderly riders with $0.50 fares for local routes and $1.00 for express routes. As stated in section 1.3, the Fairfax Connector also performs price discrimination by allowing children under the age of five to ride free when accompanied by an adult.

A reduced fare of $0.50 will generate a revenue equal to the area of $0.5*Q_1^*$, yet also generates a total cost of $\$3.00*Q_1^*$ (an explanation of calculations and derivation of $3.00 can also be found in the Appendix). Therefore a loss of $\$2.50*Q_1^*$ will be incurred due to the price discrimination of regular local route fares. Furthermore, price discrimination with respect to express routes will formulate a demand that equals to Q_1, which is the quantity demanded by non-discriminated customers at the regular $1.00 fare price; thus, the total revenue earned through $1.00 reduced fares will equal to $\$1.00*Q_1$. The cost of this low-priced fares is higher than the selling price; approximately the cost per dollar-ride will be $3.15, and therefore, net loss will equal to $\$2.15*Q_1$. A net loss of $\$2.15*\ Q_1$ was earlier recognized when the regular fare price is $1.00. The net loss of a regular $1.00 fare equals the net loss generated through price discrimination of express route fares selling at a reduced $1.00 fare, seeing that both fares are priced at $1.00. Although these net losses will not equal in reality, technically from the supply side, monopolistic suppliers either have control over price or quantity. In the case of Fairfax Connector, it has control over the price. According to theories associated with demand, selling at the same price would yield an equal quantity demanded and thus the net losses in these two scenarios would be equal to each other.

Fairfax Connector further provides free ridership to children under the age of five, when accompanied by an adult. Free ridership would not yield any revenue to the Fairfax Connector but cost approximately $2.99 per child, based on our model. The net loss due to free ridership, where total revenue (TR) is zero (TR = 0), would therefore equal to the total cost, which is $\$2.99*Q_3$.

Regardless of price discrimination, the Fairfax Connector operates under net loss. The sum of the areas of five rectangles, net loss at $1.00 regular fares ($\$2.15*Q_1$) + net loss at $3.00 regular expressed fares ($0.5*Q_2$) + net loss at 0.5 reduced-regular fares ($\$2.50*Q_1^*$) + net loss at $1.00 reduced-express fares ($\$2.15*Q_1$) + net loss at free ridership to children under the age of 5 ($\$2.99* Q_3$), represents the total loss incurred. According to empirical information, Fairfax Connector reclaimed only $4,554,929 through fare box revenues during 2005. The remaining cost—the loss incurred—was covered through government subsidies. During the year 2005, government subsidies amounted at $25,653,360.[36] When examined on a per-passenger basis, $0.53 (15%) was reclaimed via fare box revenues, while $3.03 (85%) was covered via governmental subsidy.[37]

3.2 Proposal A - Debit Card Providing Bus Fare Credit Up to $50.00 Per Month

Our first proposal (Proposal A) is to provide a debit card to low-income commuters, which would allow them to purchase up to $50.00 of fares for the Fairfax Connector each month. This debit card could only be used to pay for bus service, and we assume that there would be some type of protective mechanism that would prevent the cards from being bought and sold on the black market for less than face value.

Although public transportation has an inelastic demand, with respect to low-income households, as stated in Section 2.2, public transportation is an inferior good. As people obtain higher incomes, they shift from bus transit and subways to their private cars, resulting in a negative income elasticity of demand.[38] However, a $50 in-kind transfer is inadequate to make low-income households better off. As stated earlier, based on empirical evidence, we define low-income household as households below a $30,000 income bracket. A $50 increase would therefore generate only a 2% increase for a household with a $30,000 income. While this increase may appear to be somewhat insufficient, low-income households are less likely to easily shift from busing to other private transportation modes, making busing more of a normal good for low-income households.[39]

An increase in income will not change the existing pricing structure illustrated in the section above. However, the law of demand states, when all other factors remain constant, price and the quantity demanded has an inverse relationship. A $50 in-kind transfer would not change the fare prices, but it will increase the income of low-income households. An increase in income, which is an increase in one of the factors held constant, would shift the demand curve to the right of the existing demand curve as shown in the figure below. As a result, the total revenue would increase by the area of $1.00 * Q_1-Q_{1new}.

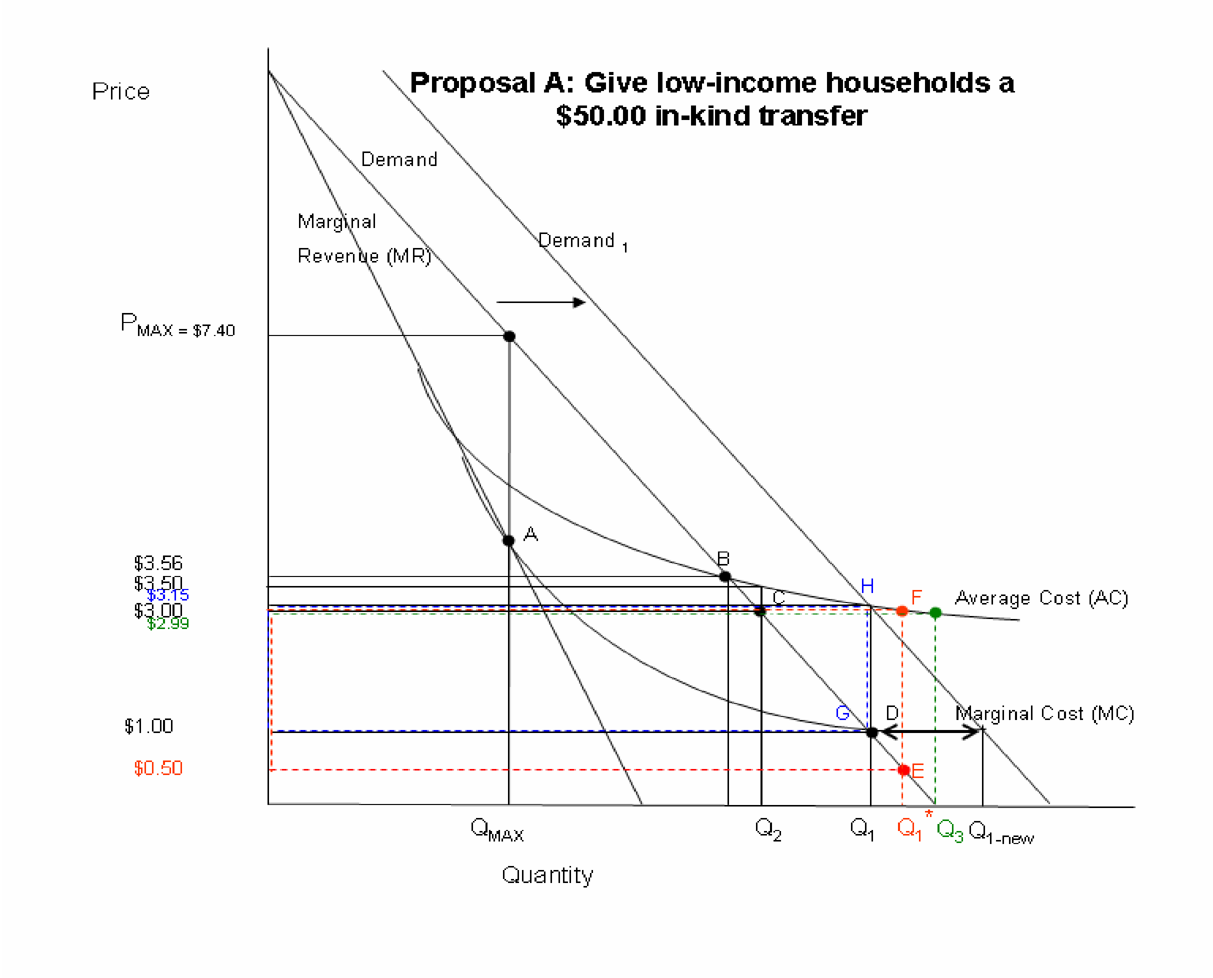

Figure 4 - Effect of Proposed Fare Subsidy

An increase in the number of passengers due to a $50.00 cash transfer is quantifiable through income elasticity of demand towards busing. However, empirical information related to income elasticity of busing, in the United States, is scarce or inapplicable. Therefore, we make an assumption that the income elasticity of busing is positive and between zero and one for low-income individuals, because public transportation is a necessity for these individuals; on the contrary, public transportation is an inferior good for the average individual, thus has a negative income elasticity. Income elasticity for busing in England is measured as -0.67, and in France, income elasticity for busing is -0.05.[40] However, the above income elasticity coefficients portray a negative correlation, because these studies have incorporated the changes in the demand for busing with respect to the changes in the income of the average individual. Our study exclusively focuses on low income individuals rather than the average individual. Due to the lack of sufficient information pertaining to low income individuals, we made an assumption that income elasticity of demand for busing among low-income households is 0.5. Income elasticity is measured as a percentage change in quantity demanded that occurs in response to a percentage change in the income.[41] A $50 increase in income for non-elderly low-income individuals with a maximum income of $30,000 would increase their income by 2% ($50*12 months). If the income elasticity is 0.5, the percentage increase in quantity demanded would be 1% (percentage increase in quantity demanded/2% = 0.5). In 2005, 2,203,277 passengers were low-income individuals, and 3.7% of all riders were over the age of 65. By subtracting the elderly percentage, we estimate that 2,121,756 riders are low-income non-elderly citizens. Therefore, this proposal should increase the quantity of low-income riders by 21,218 passengers (1%*2,121,756). However, this program will directly cost $50 per passenger, in addition to other overhead costs associated with it. If the increase in the total revenue due to the new demand is insufficient to cover the cost of this program, government subsidies are essential in order to implement this program. An increase in the quantity of passengers by 21,218 at a $1.00 fare price would yield $21,218 in revenues. As shown earlier, we are assuming that about 30,000 households in Fairfax County are considered to be low-income (our target population.) The direct cost of providing $50 debit cards for these 30,000 households is $1,500,000 ($50*30,000). The net cost of this program, $1,478,782, could be funded via federal or state grants, or financed via local government money generated through tax revenues.

In Proposal A, each low-income household is allocated with an allotment of an in-kind transfer (debit card for fares), with the assumption that bus rides are a normal good for low-income households. By allocating $50.00 per month to low-income riders, a $50.00 subsidy would yield 50 rides on a local route, or 16 rides on an express route, or any combination between 50 local rides and 16 express rides on the Fairfax Connector. Low-income households shown in Figure 5 on their initial budget line, consume both Fairfax Connector fares and other goods at an optimal level of B.

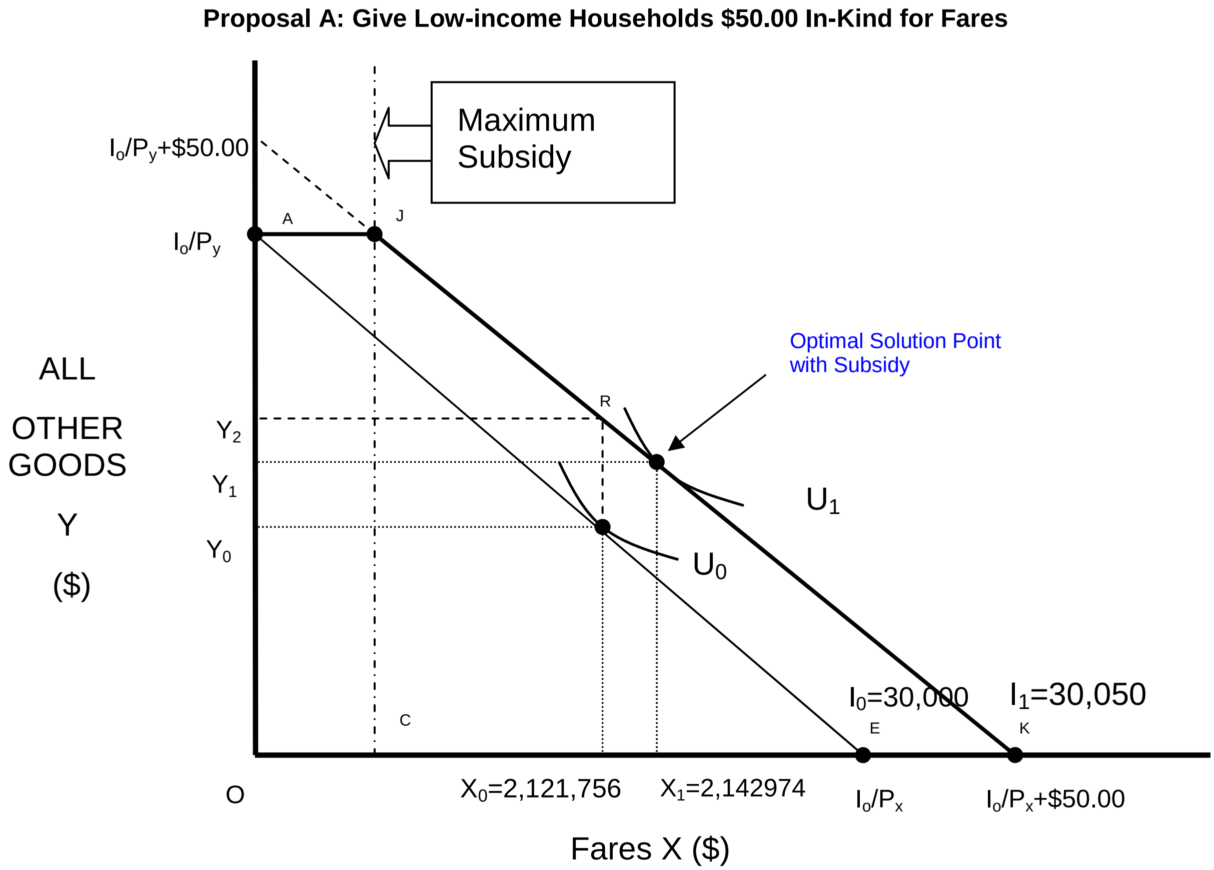

Figure 5 – Consumer Effect of a $50.00 In-Kind Subsidy to Low-income Households

Initially, the households consume X_0 of fares and Y_0 of other goods. The effect of the proposed fare subsidy on a household is illustrated in Figure 5. According to this model, AE denotes the original budget constraint at the ordinary market value, while AJK represents the revised budget constraint under the proposed fare subsidy proposal. Under the new budget constraint, households sacrifice zero dollars of other goods in order to increase their fare consumption up to J. This is due to the slope of the AJ segment of the AJK budget constraint, which is 0. Thus the marginal rate of substitution (MRS) will be zero from A through J. Since additional fares can increase utility, households will likely move to J. Therefore, it is likely that eligible households will always use the full allotment of fares. Consequently, the indifference curve on the AJK budget constraint will always be on the JK segment.[42]

It is possible to find the exact position of an optimal consumption bundle when giving low-income households a transit subsidy and knowing the income elasticity of demand. Considering the income elasticity of demand for fares is 0.5, with a subsidy of $50.00, the budget line shifts upwards a parallel amount essentially to a $50.00 increase in income. If we baseline low-income households at an average of $30,000, a $50.00 increase in income yields a 0.2% increase in income. Therefore, with a 0.2% increase in income and an income elasticity of demand of 0.5, the quantity of fares consumed and demanded increases by 0.5*0.2 = 0.1%. This therefore means that, as stated above, a $50 transfer will increase the quantity of low-income household riders by 21,218 (1%*2,121,756) passengers to X_1, which will be a quantity of 2,142,974 passengers. The consumption bundle, initially at point B, would now move to X_1; the consumption of other goods also increases from Y_0 to Y_1, as the income effect of the in-kind subsidy increases a household's purchasing power, thus allowing for less income to be used to purchase certain goods. In essence, it is as if the consumer now is somewhat "richer," and thus can afford to increase consumption of all other goods as well.

Overall, utility of a household increases after implementation to point D upon the execution of the proposal. The new consumption choice denoted by point D increases the fare consumption from X_0 to X_1. Seeing that providing all low-income households with \$50.00 fare subsidies at no cost to the recipients is similar to increasing a household's income by \$50.00, the optimal consumption bundle shifts from B to D. Accordingly, the utility level of low-income households will increase from U_0 indifference curve to (U_1), a higher indifference curve.

While this proposal does yield an increase in fare consumption, this proposal also involves a transaction cost, which will ultimately generate a cost to the tax payer. The total cost of providing all low-income households with \$50.00 at no cost to the recipients is Y_0-Y_2, thus (Y_0-Y_2) is the cost of this subsidy program.

3.3 Proposal B - Identification Card Providing Reduced Fare Purchases

Our second proposal (Proposal B) is to provide photo ID cards to low-income commuters that permit a 50% fare reduction. Essentially, this proposal affects both the suppliers and consumers of the Fairfax Connector in several differing ways. We will first consider the supply side of the Fairfax Connector. Figure 6 depicts a monopoly for the Fairfax Connector, and the effects of Proposal B's 50% price reduction for low-income persons.

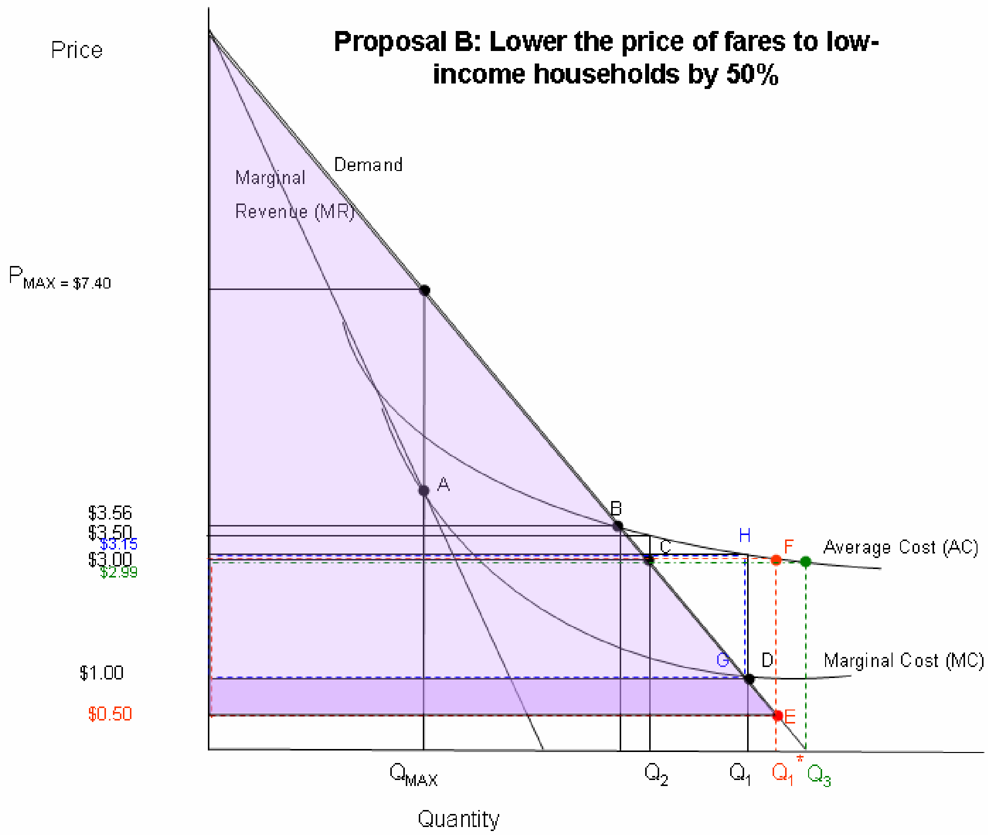

Figure 6 - Effect of Proposed Fare Reduction

As shown in Figure 6, for a monopoly to maximize profits, the quantity of a good to be produced must be where marginal revenue (MR) is equal to marginal cost (MC), in this case at point A. However, a price of P $\geq$ AC is necessary for a firm to produce in the long run and obtain profit. Any price below the average cost will not be profitable in the long run, which defines $3.56 as the firm's long-run shutdown price. From a demand and supplier point of view, reducing the price of fares to low-income households will essentially cause several effects. If prices are reduced by 50% from the original regular fare price of $1.00, the new fare price would be $0.50, at 50% of the $1.00 fare. According to the existing monopolistic pricing model for the

Fairfax Connector, a $1.00 fare will generate a demand equal to Q_1. Hence the total revenue earned through $1.00 fares will equal to the rectangle with an area of $1.00*$Q_1$. However the cost of supplying transportation services at a $1.00 fare price is much higher than the selling price; approximately the cost per one dollar-ride will be $3.15 (point H on the AC curve), and therefore net loss will equal to $2.15*$Q_1$. According to Walter Nicholson, producer surplus is described as the area up to the market price that is above the firm's average cost. Fairfax Connector generates a net loss of $2.15 per passenger and therefore results in a producer loss that is subsidized through various funding modes discussed in prior sections.

Due to the increase in cost as a result of this proposal (Proposal B), the producer loss will further widen. A $0.50 fare will generate a revenue equal to the area of 0.5*Q_1^*, yet also generates a total cost of $3.00*$Q_1^*$. Therefore a loss of $2.50*$Q_1^*$ will incur. In other words, the loss will increase from $2.15 per passenger to $2.50 per passenger, upon the implementation of this proposal. Based on the empirical evidence, 26% of Fairfax Connector's passengers in 2005 were under the low-income line. Specifically, 2,203,277 passengers were low-income individuals, in which 3.7% were over the age of 65. The Proposal B recommends a 50% reduction in the fare prices to non-adult low-income households. Incorporating the above information, we estimate that 2,121,756 individuals are low-income non-elderly adults. As mentioned in previous sections, the short run price elasticity of demand for busing is -0.28. Thus, a reduction in the fare price by 50% would increase the quantity demanded by 14%. A 14% increase in demand equals to 297,046 new passengers on the Fairfax Connector. The change in cost from the existing Fairfax Connector Model upon the implementation of this proposal would be $2.50*297,046 = $742,615 ($2.50 is the corresponding average cost of $0.50 fare prices). Therefore, total cost incurred by the implementation of this program is the

$30,208,289 of the existing Fairfax Connector model plus the new costs incurred by implementing Proposal B, $30,208,289+$742,615 = $30,950,904. Current loss per individual, $2.15 is being subsidized through various funding options, and the remaining new cost, $0.35 per individual, has to be subsidized through state or federal government grants or County of Fairfax has to increase its tax revenues to provide funding options.

From a consumer perspective, as described in Section 2.1, consumer surplus is defined as the area above the price but below the demand curve; in other words, it is the benefit gained to consumers who are paying less then they are willing to for a product. Prior to the proposed 50% price reduction, a price of $1.00 would have yielded a consumer surplus of the area below the demand curve but above $1.00-$Q_1$. With the 50% price reduction, however, the new consumer surplus is the entire shaded region of Figure 6; the area above $0.50-$Q_1$* and below the demand curve. Thus, the consumer surplus increases with Proposal B's price reduction for low-income residents. Essentially, the price reduction for the consumer yields additional benefit in the form of consumer surplus. In order to compensate for this loss and to make it profitable for the Fairfax Connector to continue to function, the government could give the Fairfax Connector a subsidy or make up the losses through taxes revenues.[43] As mentioned in previous sections, the short run price elasticity of demand for busing is -0.28. Thus, a reduction in the fare price by 50% would increase the quantity demanded by 14%.

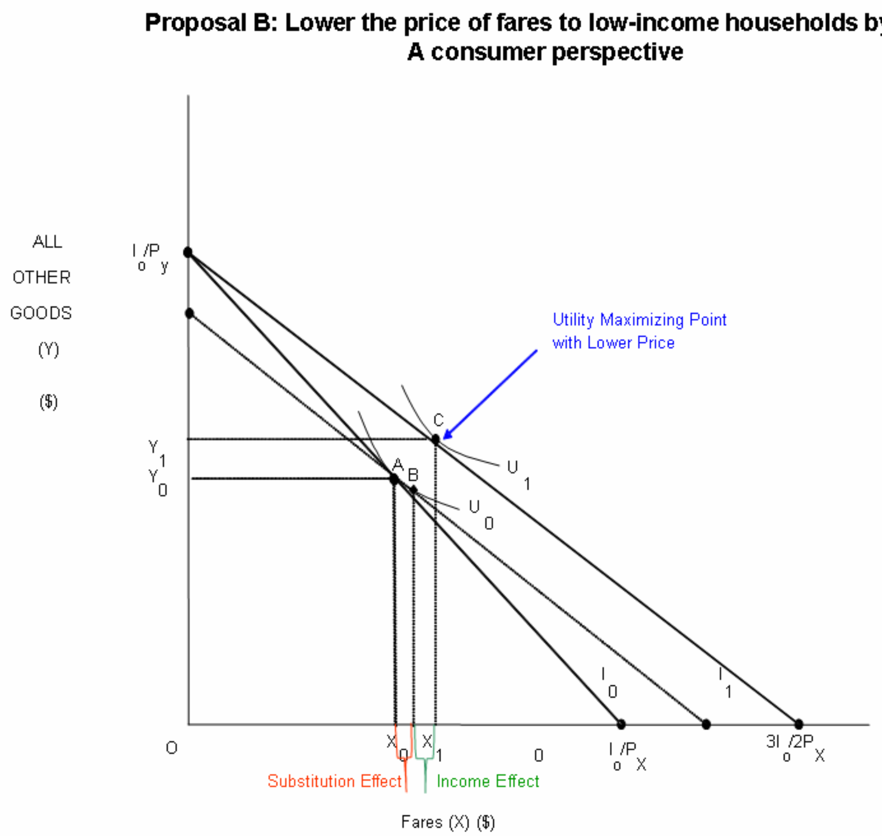

Figure 7 - Effect on Consumer Preferences

Not only does Proposal B affect consumers via consumer surplus, but it also affects consumer preferences as well, as shown in Figure 7. In general, a 50% reduction in fares is essentially a 50% reduction in price (P_X) to low-income consumers of the Fairfax Connector. In this respect, the "slope" of the low-income household's budget constraints will change because a change in P_X ultimately changes the marginal rate of substitution (MRS), and a change in MRS results in a change in the slope of a budget line.[44] Therefore, a proposal that has a 50% fare reduction will change the marginal rate of substitution (MRS) between consumption of rides on the Fairfax Connector and all other goods. This change in slope and budget constraints is demonstrated by a shift from the line formed by endpoints (I_o/P_y, I_o/P_x) to a new budget constraint with endpoints of (I_o/P_y, $3I_o/2P_x$).

With a change in price of fares on the Fairfax Connector, there are two simultaneous effects on a low-income person's consumption of rides and all other goods, the income and substitution effects. First is the "pure" price change of riding relative to the price of all other goods, which is known as the substitution effect. As expressed by Pham and Linsalata and stated above, the household's price elasticity of demand for busing ($\Delta X/\Delta P_x$) is a highly inelastic -0.28 in the short run. This means that if the price of one ride on the Fairfax Connector decreases by 1%, (ceteris paribus), the household will only demand an additional 0.28% worth of rides on the Fairfax Connector. This high inelasticity is demonstrative of a low-income household's inability to find alternative modes of transportation in the short term; with little income, it would be difficult for a low-income household to purchase an automobile or transit via cab, two modes of transportation that can be utilized in the short run but are costly relative to the Fairfax Connector fares. Thus, this inelasticity demonstrates that a low-income household has a relative stable demand for a certain quantity of rides on the Fairfax Connector and should not be expected to make drastic changes in consumption due to a change in price. This effect is measured graphically Figure 7 by paralleling the new (I_1) budget constraint onto the original indifference curve (U_0) and determining the point of tangency. The substitution effect is therefore reflected in the shift from point A to point B (AB).

The second effect is the income effect, which occurs when a decrease in price of a good ultimately increases the purchasing power of the consumer. This effect is measured graphically Figure 7 by the distance from point B to point C (BC), which is the point of tangency on the new indifference curve (U_1).[45]

Looking at both effects in a comprehensive manner, a price elasticity of demand for buses in the short run of -0.28 and a decrease in price by 50%, yields 50*(0.28) = 14% and, thus, consumption of fares for the Fairfax Connector should increase by 14%. This reflects the fact that the low-income households are relatively satisfied with their current level of fare consumption. Any changes in its budget constraint will largely be devoted towards the purchase of all other goods, rather than further purchases of fares for the Fairfax Connector.

In evaluating the additional utility gained for low-income persons from implementing this proposal, it can be stated that a reduction in the price of Fairfax Connector fares by 50% clearly results in an increase in utility for low-income households. A household is able to shift from its original indifference curve (U_0) to a new, higher indifference curve (U_1). Thus, in terms of overall utility, the low-income household is better off after the program than before the program.

4. Recommendations

To summarize the calculations noted in Section 3, Proposal A provides a debit card to low-income households that would allow them to purchase up to $50.00 of fare for the Fairfax Connector each month. This will increase their annual income by $600 ($50 * 12 months). However, as illustrated earlier, an annual increase of $600 would only yield a 1% increase in the demand. This is mainly due to the income elasticity of demand, 0.5, which we incorporated for our calculations. A 1% increase in demand in reality would increase the non-elderly low-income commuters by 21,218. This would generate total revenue of $21,218 at a $1.00 fare price. Although the quantity increases by 21,218 passengers, all low-income households will receive the $50 debit card. The estimated cost of $1,478,782 would be subsidized through government funding, and yet this is a substantially large amount to be allocated for one public transportation provider. However, this amount might overstate the cost of the program, due to consumer behavior of low-income commuters. If the target population refrains from using these debit cards frequently, the program cost will decrease. Additionally, each "ride" as measured above is considered to be a separate person, when in reality, a person may be a frequent user, accounting for more than one ride. Also, some households may only use the cards a few times per month, while others may exhaust the $50 value in the first week. Each household will only receive one monthly card; regardless of how many times a household member is a passenger on the Connector per month.

In contrast, due to a price elasticity of demand measured at -0.28, Proposal B would yield a 14% increase in the quantity demanded as mentioned in section 3.3. Specifically, the number of low-income commuters would increase by 297,046, and the total revenue will increase by $148,523. Both the increase in quantity and the total revenue is higher than Proposal A's corresponding increases. Proposal B will cost $742,615, about one-half the cost of implementing Proposal A at $1,478,782.

Due to the higher quantity of low-income passengers that Proposal B generates in addition to the higher total revenue and lower cost than the first proposal, we recommend Proposal B as the most feasible option to increase low-income ridership. Therefore, we propose photo ID cards be provided to low-income commuters, which allow a 50% fare reduction. A regional employment elasticity of demand for bus transit is 0.25, meaning that, as mentioned in Section 2.2, a 1% increase in employment would yield a 0.25% increase in bus ridership.[46] Therefore, with a 14% increase in bus ridership in Proposal B and a regional employment elasticity of demand for bus being 0.25, 14%/.25=56%. This means that Proposal B would ultimately yield a 56% increase in employment for low-income workers riding the bus, where increasing the employment of low-income workers is an ultimate goal of this paper.

As a result of the increased ridership that would result from the implementation of Proposal B, several indirect and beneficial effects occur, which can be considered in some respects to be positive externalities of implementing Proposal B. With more persons transiting via bus, there will be less congestion than if bus users would have been driving (assuming that buses take the same route as cars). Furthermore, with fewer vehicles on the road, all vehicles will take less time commuting. Less commuting time ultimately increases parking accessibility, decreases the costs of gas used per commute to work, increases travel options, reduces pollution, and reduces the probability of accidents.[47] Regardless of these benefits, the effects of Proposal B on the positive externalities it instills is beyond the scope of this paper but can be considered for future research.

While there are benefits to the implementation of Proposal B, the costs of this proposal must be considered as well. The costs associated with the supply side of the monopolistic model could be covered through the revenues that it generates. $148,523 worth of revenue is being generated and could cover a portion of the cost. The remainder of the cost, in other words, the loss should be financed via federal or state subsidies or the local government, should be financed through tax revenues. However, financing through tax payer dollars will increase the tax payers' burden, because this would limit the budgetary allocations into other sectors that benefits tax payers. This notion, too, however is beyond the scope of this paper.

5. Summary and Conclusions

Subsidizing public transportation will provide low-income residents with the necessary transportation options to expand their employment opportunities. It is hoped that by enacting such a program, these residents will be able to pursue job growth in parts of the county that may have previously been inaccessible.   In examining this type of program, it should be recognized that several additional factors must be taken into account by those charged with its implementation.

First, it must be acknowledged that any such aid to transportation may only be a short-term fix. Once low-income residents raise their income by obtaining higher paying jobs, they will likely discontinue use of the Connector due to its status as an inferior good in households with higher income levels. This should not be viewed as a negative factor of such a program, but rather a reflection of society's preference for single occupancy vehicles over public transportation. Regardless, given the nature and demographics of the Washington Metropolitan area, many young people are constantly moving into the area in order to gain experience, and in many cases holding positions that are at or near low-income levels. Therefore, through the influx of young professionals seeking experience and the highly transient immigration population in Northern Virginia, it can be surmised that a steady influx of new low-income families into the county will continually occur. Thus, a proposal such as Proposal B may not be truly a temporary fix, provided that low-income families are continuously moving into Fairfax County and the low-income population is constantly turning over.

Second, an examination must be made of possible funding sources for such a program. Since this is a program designed to increase the economic livelihood of county citizens, as well as decrease traffic, it may be possible to seek a one-time grant from the state or federal government to implement the program. However, since Fairfax County has traditionally operated in a budget surplus, the county will likely have to provide some share of the cost.

Third, in the case of either proposal, additional ridership will lead to additional requirements for the Connector in infrastructure, which has not been captured in this model and is beyond the scope of this paper. These costs include—but are not limited to—increased wear and tear on existing buses, higher maintenance and upkeep, and increased fuel expenditures. Further analysis may lead to the conclusion that additional buses, drivers, and routes are required to service the increased ridership. The overall effect of such changes would increase variable operating costs.

Lastly, it is important to note that this type of program should not be viewed as a panacea but rather a part of a larger systematic approach by both Fairfax County and higher levels of government to improve the status of its most needy households. In conjunction with these other programs (which include welfare, subsidized housing, and educational and training programs), it is hoped that low-income households can be given a much needed leg-up.

6. Appendix: Cost Calculation Methodology for the Monopolistic Model

As mentioned earlier, during the fiscal year 2005, Fairfax Connector transported 8,474,143 passengers.[48] In order to calculate the average cost (total cost/quantity), 8,474,143 is taken as the quantity, while the total cost for the same period amounted to $30,208,289. Mathematically:

$$AC = TC / Q$$

$$AC = \$30{,}208{,}289 / 8{,}474{,}143$$

$$AC \approx \$3.56$$

As shown in the graph below, at point B the demand curve intersects the average cost curve, and thus the profits [total revenue – total cost; or quantity demanded*(selling price – average cost)] will equal to zero. Point B, which is the break even point for this model, can be defined as the point where the total revenue equals to the total cost or where the price equals to the average cost (P = AC). As calculated above, the average cost based on the annual information provided by the Fairfax Connector bus system would be $3.56. At the break-even point, average cost should equal to the selling price. Hence, the break-even price is $3.56.

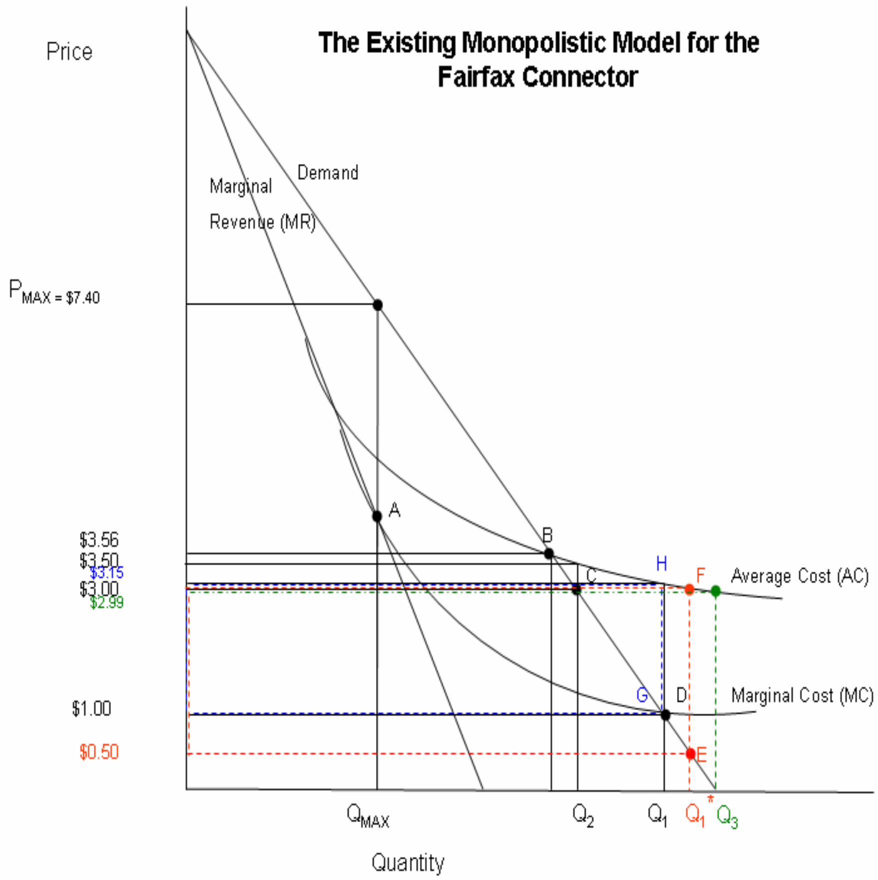

Figure A-1 Calculating the Fares and Costs for the Existing Model of the Fairfax Connector

According to the model developed, the distance between the origin and the break-even price is 1.3 inches. By dividing the average cost ($3.56) by 1.3 inches, we estimated that 0.1 inches represent approximately $0.27 ($3.56/13 = 0.27…). Figure A-2 explains this graphically.

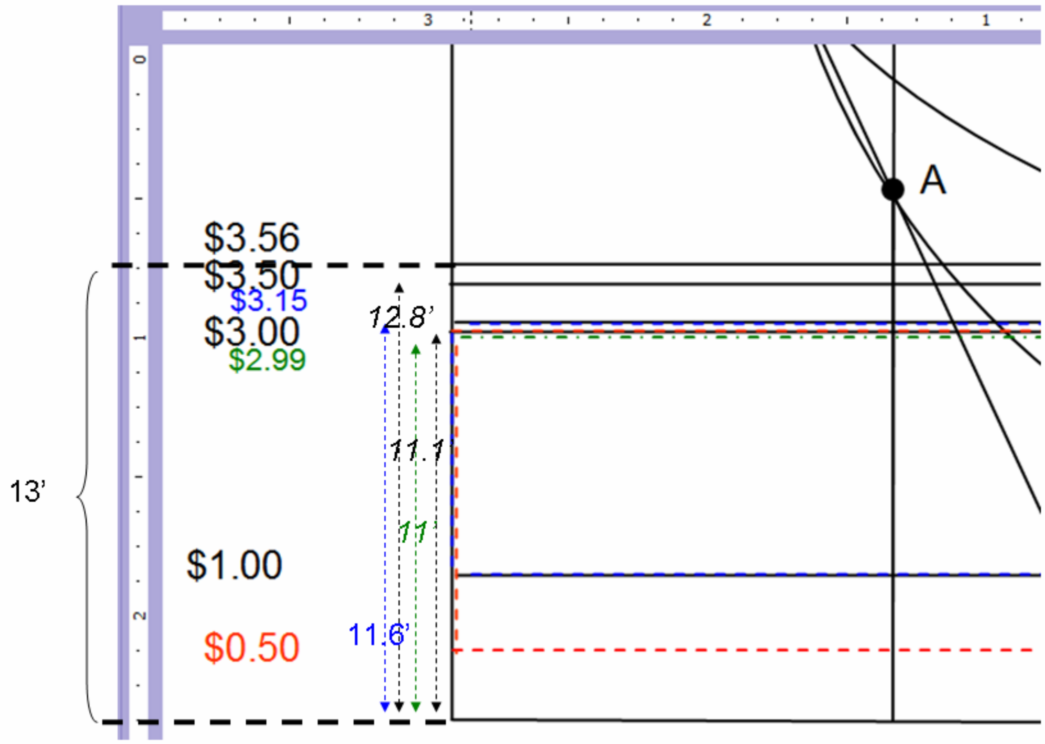

Figure A-2 A Breakdown of the Calculations for the Fares and Costs of the Existing Fairfax Connector Model

The cost of supplying transportation services at a $1.00 regular and reduced fare prices approximately cost $3.15 on each occasion. This cost is estimated by extending Q_1 up to the average cost curve and then measuring the distance on the price axis: the distance between the origin and the average cost. The distance, as shown in the graph above amounts up to 11.6; hence the cost will be 11.6*0.27…., which approximates to $3.15. Similarly, the cost of express fares can be calculated. The distance between the average cost of the express fares and the origin is 12.8 according to the above figure; and therefore the average cost will approximately amount up to $3.50 (12.8 * 0.27…). Providing free rides to children costs approximately $2.99, according to our model. This amount is estimated by multiplying the distance between the origin and the cost, 11, with 0.27… Similar to these cost calculations, all other costs included in this report were calculated utilizing the same methodology.

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