



Metro

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NOVEMBER 18, 2011

TO: BOARD OF DIRECTORS

**THROUGH: ARTHUR T. LEAHY
CHIEF EXECUTIVE OFFICER**

**FROM: NALINI AHUJA
EXECUTIVE OFFICER, OFFICE OF MANAGEMENT AND BUDGET**

SUBJECT: ANALYSIS OF FACTORS AFFECTING BOARDINGS

ISSUE

In response to Director Najarian's request for information regarding the effect of fare changes on Metro boardings, and the CEO's request to include Metrolink in the discussion, the following is an analysis of some factors including fare changes affecting Metro and Metrolink boardings.

DISCUSSION

We analyzed the impact of factors such as fares, gasoline price and employment on Metro Boardings from Fiscal Year (FY) 2007 to FY 2011. A study identifying the effects of the same factors on Metrolink ridership was provided by Southern California Regional Rail Authority (SCRRA) for the period FY 2001 to FY 2009 and is included in this report as well.

To be consistent with the analysis of Metro boardings we have also analyzed the effect of these factors on Metrolink boardings for FY07 to FY11 period.

METRO

Factors Affecting Metro Boardings (FY 2007- FY 2011)

The process was initiated by identifying a range of factors that could potentially impact Metro boardings, such as price of unleaded gasoline, Los Angeles County employment and average fare increases.

A. Impact of Price of Unleaded Gasoline on Boardings (Attachment A)

Bus Boardings

Metro bus boardings went down when price of gasoline went up in FY08, FY10 and FY11. In FY09 the price of gas dropped by 16.5% and boardings remained unchanged.

With increasing gas prices bus boardings were expected to increase as well. However, that was not the case during our study period, showing that gas prices did not have a significant impact on Metro bus boardings. The trend of bus boardings has been downward during this period.

Accordingly, the impact of gas prices was not as significant as other factors on Metro bus boardings.

Rail Boardings

There was no detectable relationship between Metro rail boardings and price of gas other than for the Metro Gold Line where the ridership kept going up during this period. It should be noted that the Metro Gold Line service was extended to East Los Angeles in November 2009 partially contributing to this ridership increase.

B. Impact of Employment on Boardings (Attachment B)

Bus Boardings

In FY08, Los Angeles County employment increased by 4.9% but bus boardings declined by 6.3%. The decline in Metro bus boardings could be explained by a 10% increase in average fares.

Los Angeles County employment went down during FY09, FY10 and FY11 so did Metro bus boardings.

Therefore, LA County employment decline negatively impacted bus ridership.

Rail Boardings

In FY08, Los Angeles County employment increased by 4.9% and Metro Gold Line boardings increased by 10.5%.

Los Angeles County employment decline in FY09, FY10 and FY11 did not seem to have an impact on the Metro Gold Line boardings which increased regardless.

In FY08 and FY09, other Metro rail boardings increased by 5.1% and 6.6% respectively when LA County employment increased by 4.9% and decreased by 7.6% respectively.

In FY10, other Metro rail boardings remained unchanged when LA County employment decreased by 4%, and in FY11 other Metro rail boardings decreased by 1.1% when LA County employment remained almost unchanged.

Therefore, there was also no noticeable relationship between Metro rail boardings and Los Angeles County employment.

C. Impact of Average Fare Increases on Boardings (Attachment C)

Bus Boardings

From FY07 to FY08 average fares increased by 10% and Metro bus boardings decreased by 6.3%.

From FY08 to FY09 average fares remained unchanged and bus boardings declined slightly (0.4% decrease).

From FY09 to FY10 average fares remained unchanged and bus boardings decreased by 5.2%.

From FY10 to FY11 average fares increased by 10%. During this period Metro bus boardings decreased by 2.4%.

In spite of having the same percentage increases (10%) in average fares in FY08 and FY11, Metro bus boardings did not decrease in FY11 by the same rate as it did in FY08. The continuous drop in ridership in prior years, specifically 5.2% ridership decrease in FY10 was the result of cumulative decreases in LA County employment during FY09 and FY10. The lower ridership base in FY10 could be the contributing factor to the smaller percentage decrease in ridership in FY11 in spite of having the same percentage of average fare increases as in FY08.

Fare increases negatively impacted Metro bus boardings.

Rail Boardings

From FY07 to FY08 average fares increased by 10%. During this period Metro Gold Line boardings increased by 10.5%, and other Metro rail boardings increased by 5.1%.

From FY08 to FY09 average fare remained unchanged. During this period Metro Gold Line boardings increased by 14.2%, and other Metro rail boardings increased by 6.6%.

From FY09 to FY10 average fare remained unchanged. During this period Metro Gold Line boardings increased by 22.4% partially due to Metro Gold Line Eastside Extension (MGL EE), and other Metro rail boardings remained unchanged.

From FY10 to FY11 average fares increased by 10%. During this period, Metro Gold Line boardings increased by 23%, and other Metro rail boardings decreased by 1.1%.

Fare increases did not seem to significantly impact rail boardings.

METROLINK

Factors Affecting Metrolink Boardings (FY 2001- FY 2009) (Attachment D)

During FY01 – FY09 changes in the price of gasoline appeared to be consistently the most important variable governing changes in ridership. This was due in large part to the magnitude of its changes over this period. The highest price for unleaded gasoline during the period was more than four times the lowest price.

The magnitude of the changes in gasoline prices might have resulted in other factors appearing less important than they actually were. This was especially true of non-farm employment, which had a significant correlation with unleaded gasoline prices.

The elasticities generated by this model suggested that:

- 10% increase in price of gas resulted in 1.15% in ridership gain;
- 10% increase in Los Angeles Metropolitan Statistical Area Non-Farm Employment resulted in 3.38% ridership gain;
- 10% increase in average fares resulted in 2.14% decrease in ridership;
- 10% increase in Train Miles of Service resulted in 1.3% ridership gain;
- And, 10% increase in weekend ridership resulted in 0.54% increase in ridership (Attachment D).

A. Impact of Metrolink Average Fare Increases on Boardings (Attachment E)

The result of our analysis of Metrolink ridership report is as follows:

- In FY08 average fares increased by 3.5% and boardings went up by 4.5%.
- In FY09, average fares increased by 5.5% and boardings went up by 2.4%.
- In FY10 average fares increased by 3% and boardings went down by 8.7%.
- In FY11 average fares increased by 6% and boardings went down by 1.6%.

In FY10 Metrolink boardings decreased significantly in spite of having less increases in average fares compared to FY09 (3% versus 5.5%), which shows that other factors, such as employment and/or price of gas have bigger impact on Metrolink boardings.

B. Impact of Employment and Price of Gas on Metrolink Boardings

In FY08, Metrolink systemwide ridership increased by 4.5%, LA County employment increased by 4.9% and price of gas increased by 16.1%. Therefore, the increase in LA County employment and price of gas could be leading factors to increase in ridership.

In FY09, Metrolink ridership increased by 2.4%, LA County employment decreased by 7.6% and price of gas decreased by 16.5%. The smaller increase in ridership in FY09 compared to FY08 could be explained by the decline in LA County employment and the significant drop in price of gas.

In FY10, Metrolink ridership dropped by 8.7%, price of gas increased by 7.4% and LA County employment decreased by 4%. Therefore, in FY10 the impact of LA County employment on Metrolink ridership was greater than the impact of gas prices.

In FY11, Metrolink ridership dropped by 1.6%, LA County employment remained almost unchanged and price of gas increased by 16.4%.

Prices of gas impacted Metrolink boardings; however LA County employment had bigger impact on Metrolink boardings compared to price of gas.

NEXT STEPS

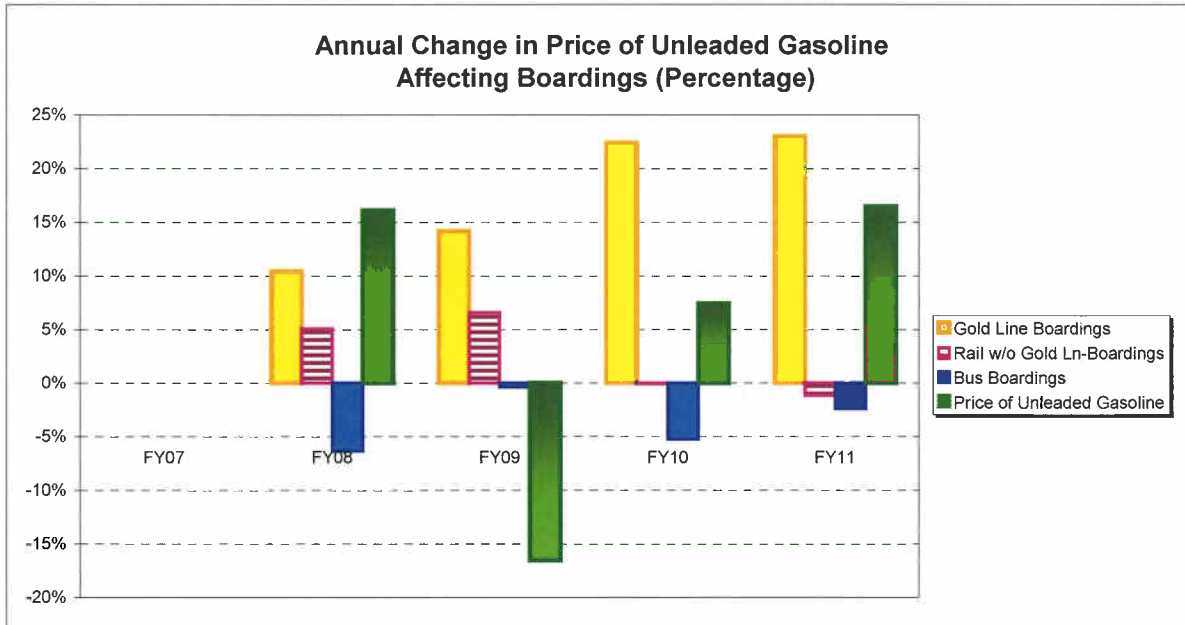
We will monitor the factors impacting boardings and in case of any deviation from the current trend we will get back to the board with updated information.

ATTACHMENTS

- A. Annual Percentage Change in the Price of Unleaded Gasoline Affecting Metro Boardings
- B. Annual Change in Employment Affecting Metro Boardings
- C. Annual Change in Average fares Affecting Metro Boardings
- D. Metrolink Ridership Modeling (provided by SCRRA)
- E. Metrolink Annual Change in Average fares Affecting Boardings

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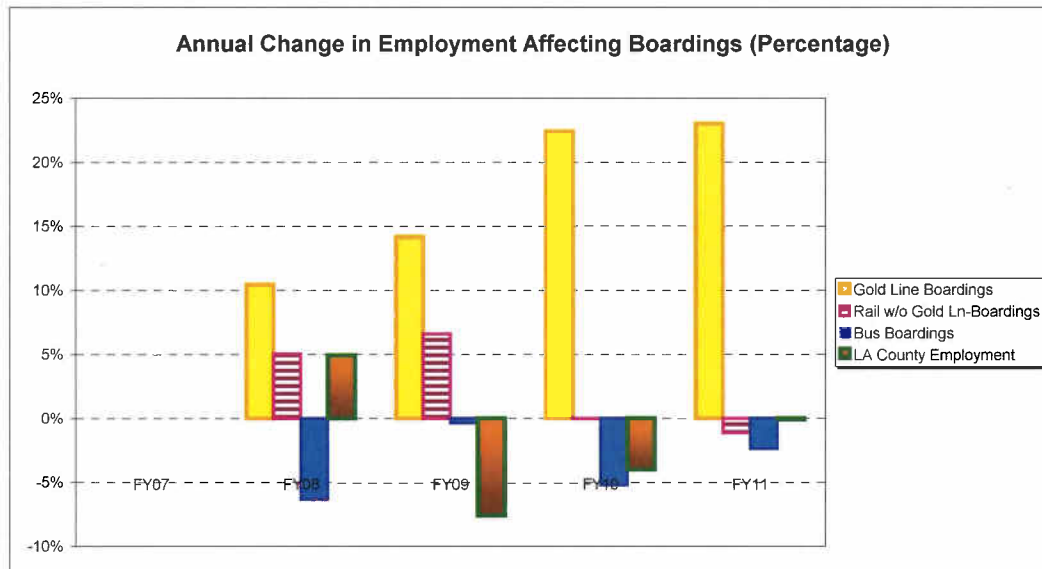
Annual Change in the Price of Unleaded Gasoline Affecting Metro Boardings



Fiscal Year	Gold Line Boardings	Annual Change in Gold Line Boardings	Rail w/o Gold Ln-Boardings	Annual Change in Rail w/o Gold Line Boardings	Bus Boardings	Annual Change in Bus Boardings	Price of Unleaded Gasoline	Annual Change in Unleaded Gasoline Price
FY07	5,955,172		76,273,500		413,684,065		\$2.92	
FY08	6,577,690	10.5%	80,129,450	5.1%	387,521,565	-6.3%	\$3.39	16%
FY09	7,510,300	14.2%	85,408,228	6.6%	386,160,348	-0.4%	\$2.83	-17%
FY10	9,192,624	22.4%	85,369,993	0.0%	365,971,033	-5.2%	\$3.04	7%
FY11	11,306,314	23.0%	84,399,730	-1.1%	357,257,675	-2.4%	\$3.54	16%

- Bus boardings go down and the price of gas goes up particularly in FY08, FY10 and FY11.
- In FY09 the price of gas decreases by 16.5% and bus boardings remain unchanged.
- Price of gas does not explain bus ridership as significantly as employment does.
- There is no detectable relationship between rail boardings and price of gas including Gold Line where the ridership keeps going up during this period.

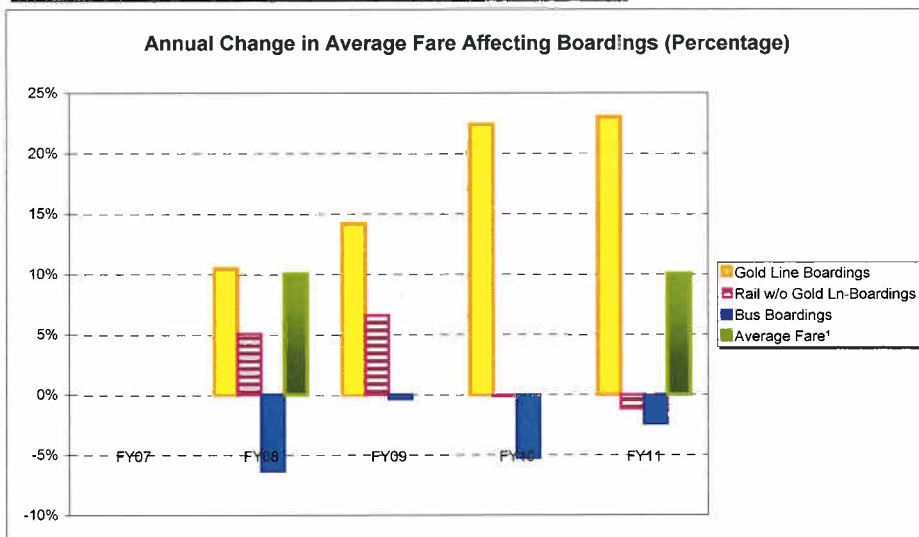
Annual Change in Employment Affecting Metro Boardings



Fiscal Year	Gold Line Boardings	Annual Change in Gold Line Boardings	Rail w/o Gold Ln Boardings	Annual Change in Rail w/o Gold Line Boardings	Bus Boardings	Annual Change in Bus Boardings	LA County Employment	Annual Change in LA County Employment
FY07	5,955,172		76,273,500		413,684,065		4,596,125	
FY08	6,577,690	10.5%	80,129,450	5.1%	387,521,565	-6.3%	4,822,775	4.9%
FY09	7,510,300	14.2%	85,408,228	6.6%	386,160,348	-0.4%	4,455,717	-7.6%
FY10	9,192,624	22.4%	85,369,993	0.0%	365,971,033	-5.2%	4,276,417	-4.0%
FY11	11,306,314	23.0%	84,399,730	-1.1%	357,257,675	-2.4%	4,271,642	-0.1%

- LA County employment goes down during FY09, FY10 and FY11 so do bus boardings.
- Metro Gold Line Eastside Extension (MGLEE) opened in November 2009 (FY10).
- LA County employment decline does not seem to have an impact on the Gold Line boardings in FY09, FY10 and FY11, which have increased regardless.
- In FY08, other Metro rail boardings increased by 5.1% when LA County employment increased by 4.9%.
- In FY09 other Metro rail boardings increased by 6.6% when LA County employment decreased by 7.6%.
- The boardings remained unchanged in FY10 when LA County employment decreased by 4%.
- Other Rail boardings decreased by 1.1% in FY11, but LA County employment remained almost unchanged.
- There was no noticeable relationship between Metro rail boardings and Los Angeles County employment.

Annual Change in Average Fare Affecting Metro Boardings



Fiscal Year	Gold Line Boardings	Annual Change in Gold Line Boardings	Rail w/o Gold Ln-Boardings	Annual Change in Rail w/o Gold Line Boardings	Bus Boardings	Annual Change in Bus Boardings	Weekly Pass	Day Pass	Cash Fare	Monthly Pass	Average Fare Increase
FY07	5,955,172		76,273,500		413,684,065		\$ 14.00	\$ 3.00	\$ 1.25	\$ 52.00	0%
FY08	6,577,690	10.5%	80,129,450	5.1%	387,521,565	-6.3%	\$ 17.00	\$ 5.00	\$ 1.25	\$ 62.00	10%
FY09	7,510,300	14.2%	85,408,228	6.6%	386,160,348	-0.4%	\$ 17.00	\$ 5.00	\$ 1.25	\$ 62.00	0%
FY10	9,192,624	22.4%	85,369,993	0.0%	365,971,033	-5.2%	\$ 17.00	\$ 5.00	\$ 1.25	\$ 62.00	0%
FY11	11,306,314	23.0%	84,399,730	-1.1%	357,257,675	-2.4%	\$ 20.00	\$ 5.00	\$ 1.50	\$ 75.00	10%

- From FY07 to FY08 average fare increased by 10%:
 - Bus boardings decreased by 6.3%.
 - Gold Line boardings increased by 10.5%.
 - Other Metro rail boardings increased by 5.1%.
- From FY08 to FY09 average fare remained unchanged:
 - Bus boardings declined slightly (0.4% decrease).
 - Metro Gold Line boardings increased by 14.2%.
 - Other Metro rail boardings increased by 6.6%.
- From FY09 to FY10 average fare remained unchanged:
 - Bus boardings declined by 5.2%.
 - Metro Gold Line boardings increased by 22.4%.
 - Other Metro rail boardings remained unchanged.
- From FY10 to FY11 average fare increased by 10%:
 - Bus boardings declined by 2.4%.
 - Gold Line boardings increased by 23%.
 - Other Metro rail boardings declined by 1.1%.

Fare increases negatively impact Metro bus boardings.

Fare increases do not impact Metro rail boardings.

Metrolink Ridership Modeling

Technical Memorandum No. 1 (Final): *Development of Metrolink Ridership Model*

Submitted to

Southern California Regional Rail Authority

Submitted by

TranSystems
and
LTK Engineering Services

March 2010

This Technical Memorandum describes the process followed in developing a Ridership Model for Metrolink. SCRRA requested the development of a model designed to identify the contributory effects of factors that determine Metrolink ridership and which could estimate the effects of various policy options, such as changes in fares and services levels, as well as the effects of external factors, such as changes in gasoline prices or employment. The Ridership Model is being designed to be maintained by SCRRA staff.

1. Data Collection

SCRRA and TranSystems staff began by the modeling process by identifying a range of factors that were believed to potentially impact SCRRA ridership. These factors included the following:

- Employment, unemployment and labor force in LA and Orange Counties, as well as non-farm employment in the Los Angeles MSA
- Fares
- Cost of unleaded gasoline
- Service level on each line
- On-time performance
- Auto travel time and reliability (e.g., traffic delays and congestion issues)
- Service Interruptions (e.g., strikes and accidents)
- System expansions
- Population in LA and Orange Counties
- Population in surrounding counties
- Service quality (e.g., cleanliness and courtesy)
- Parking prices

Because of changes in Metrolink's fare equipment and ridership data, the focus of the project was on analyzing ridership from July 2000 to June 2009. Because maximizing the number of time points analyzed is very important in maximizing the accuracy of a model, the decision was made to analyze monthly data rather than annual data.

However, some of these factors are not measured monthly -- or records are not available. This required us to eliminate auto travel time and reliability, population and parking prices from consideration in the model. Furthermore, service quality was limited to consideration of on-time performance.

2. Model Design

There are many potential ways to design a ridership model. The most basic method is to do a linear regression of ridership against the potential factors, eliminating those factors that prove to have either limited predictive value or that are too closely related to other factors (e.g., employment and congestion tend to be closely related). The disadvantage of this method is that it is strongly impacted by the base ridership in the system and less sensitive to how that ridership has changed in each month.

To address this issue, we focused our work on two alternative model designs. One alternative is what is known as a *log-log model*, in that the model is calculated using the logarithms of both ridership and each of the factors. The second alternative is a *percent change model*, which analyzes the year-over-year percent

change in ridership based on the year-over-year percent changes in the factors. In both of these types of models, the results can be easily converted to elasticities. The major difference between them is in how they treat interactions among factors. The first of these models offers an advantage in that it allows the use of an additional year of data, while the second model offers an advantage in that it eliminates calendar impacts (e.g., holidays and the starting and ending of school) from having to be considered.

3. Model Development

The process followed in developing the draft model consisted of testing multiple combinations of potential factors and analyzing each alternative based on the following:

- Accuracy in explaining changes in ridership
- Direction of the impacts of each factor (e.g., a model where fare increases or service reductions increase ridership is not considered reasonable)
- Quantitative reasonableness of the impacts of each factor (e.g., a model where fare changes have an elasticity of close to or over -1.0 is not considered reasonable)
- The statistical significance of the variables included in the model.

The analysis has looked at multiple ways that the factors could influence ridership, including the following:

- Immediate impacts – a change in ridership occurs when the change occurs in the other factor
- Lagging impacts – a change in ridership occurs a month or two after the change in the other factor
- Leading impacts – a change in ridership occurs before the change in the other factor, such as riders reacting to an announcement of changes in fares or service levels
- Shock impacts – where a large change in a factor causes a greater than proportional change in ridership, such as where a 10% increase in fares causes more than twice the ridership change of a 5% increase in fares

The different combinations of factors and the different treatments of the factors has resulted in a huge number of models that could be created.

4. Modeling Results

Key findings of the modeling process include the following. First, during the period being analyzed, there were some unexpected correlations in how some of the factors changed. These included the following:

- A tendency for changes in the price of unleaded gasoline to track changes in employment in LA and Orange Counties
- A tendency for weekend service levels to generally trend with fare increases and increases in non-farm employment

Not surprisingly, the system-wide train miles of service provided also tracks with the opening of new stations and new lines. Separating the impacts of factors that track each other generally results in the more important of the two factors showing an excessively strong impact and the less important factor(s) showing little impact (or possibly a counter-intuitive impact).

The initial results indicate that the most important factors determining changes in weekday ridership are the following:

- Changes in the price of unleaded gasoline
- Changes in weekend ridership during the previous month (compared with the previous year)
- The opening of new lines
- Changes in service levels
- Changes in non-farm employment
- Changes in fare levels
- Special occurrences, such as performing trackwork and the closing of Route 14

Changes in the price of gasoline appear to be consistently the most important variable governing changes in ridership. This is due in large part to the magnitude of its changes over this period; the highest price for unleaded gasoline during the period was more than four times the lowest price. In comparison, the highest ridership was 70% higher than the lowest ridership, the highest train-miles of service was 44% higher than the lowest, the highest fares were 31% above the lowest, and the highest non-farm employment was only 6% higher than the lowest. As a result of the magnitude of the changes in gasoline prices during this period, it is important to note that the magnitude of the changes in gasoline prices may have resulted in other factors appearing less important than they actually are. This is especially true of non-farm employment, which had a significant correlation with unleaded gasoline prices.

The elasticities generated by this model are as follows:

Unleaded Gasoline	0.115 (10% gain results in 1.15% ridership gain)
Los Angeles MSA Non-Farm Employment	0.338 (10% gain results in 3.38% ridership gain)
Average Fares	-0.214 (10% increase results in 2.14% ridership loss)
Train-Miles of Service	0.13 (10% gain results in 1.3% ridership gain)
Weekend Ridership	0.054 (10% gain results in 0.54% ridership gain)

In addition, opening a new line appears to cause a 1.25% increase in ridership. Months when significant trackwork was conducted on the lines showed a 4.3% decrease in ridership while the month in which Route 14 was shut (December 2007) showed a 6% higher ridership than otherwise expected. In addition there is a constant term of a year-over-year increase in ridership of 3.1%, which probably reflects in large part the increases in the regional population.

The adjusted R-squared of this model is .5589, which means that it explains about 56% of the change in ridership of any month compared with the same month of the previous year. Looking over the period from July 2001 through July 2009, this means that for any single month the model predicted between 10.1% high and 5.6% low from the actual ridership. Ninety percent of the results were between 3.8% high and 4.6% low. However, for any consecutive 12 month period (ending June 2002 through July 2009), the model predicted a ridership that was between 2.0% high and 2.6% low. Ninety percent of the results for 12-month periods were between 1.3% high and 1.8% low.

5. Testing and Final Adjustment of Model

While this model showed strong results the model's accuracy for FY 2009 and the early months of FY 2010 were unsatisfactory. A review of the model and types of changes occurring during this period identified two principal factors and one minor factor leading to the errors, these were:

- There were very large year over year changes in the price of gasoline during this period, including the first time gas prices exceeded \$4.00. A review of the data indicated that rather than riders becoming increasingly sensitive to changes in gas prices as the change in prices increases, riders become less sensitive, e.g., a 40% increase in gas prices has less than twice the impact of a 20% increase in gas prices. The exception to this is when gas prices first break through psychologically significant levels, such as the \$4.00 level which occurred in June 2008.
- The basic design of the model, focusing on year-over-year changes in ridership as a result of year-over-year changes in gas prices, fares and employment, means that if ridership is unexpectedly high or low in one month, the model will assume that the trend will continue into the following year. This meant that model under-predictions of ridership for FY 2009 resulted in over-predictions of ridership for FY 2010.
- When looking ahead two or three months, if the model is currently significantly under-predicting or over-predicting ridership and it has done so for the several months in a row, the unknown factor(s) causing the under or over prediction will likely continue to impact the predictions although it will slowly disappear. Therefore the next few months should be adjusted to counter the assumed continuing, but decreasing, impact of the unknown factor(s).

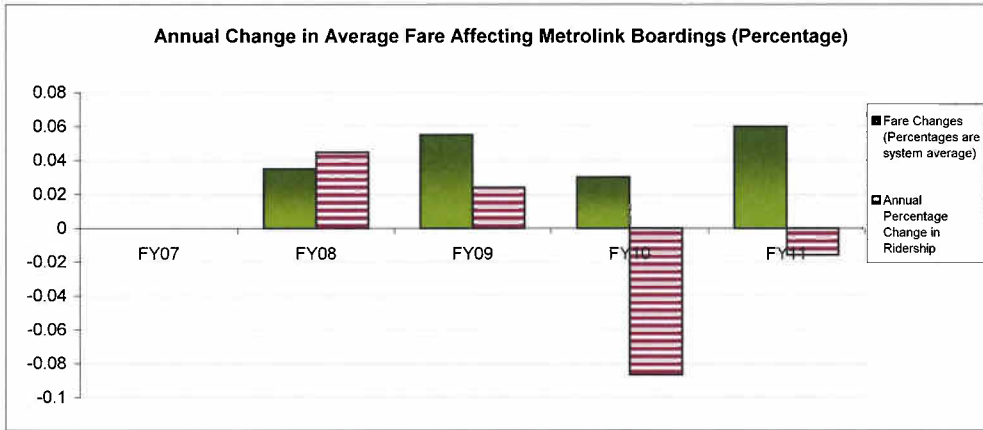
The final model, including these adjustments, is that the ridership for any given month equals the ridership for the same month in the previous year, times the product of the following:

- One plus 0.11530606 times the percentage change in the gas prices of the previous month, raised to the power of 0.6, except that if gas prices break through a new psychologically important level this factor is increased by an additional 30%
- One plus 0.33767387 times the percentage change in non-farm employment
- One minus 0.21357874 times the percentage change in the average fares charged by the agency for the previous month
- One plus 0.1309719 times the percentage change in the train-miles of service provided
- One plus 0.045 times the percentage change in weekend ridership for the previous month

However, if the model substantially under-predicted ridership for the same month in the previous year, that higher than expected ridership is assumed to have been the result of transitory factors which would not continue. Therefore, the model adjusts the ridership down by the percentage that ridership was under-predicted in the previous year. Finally, the model examines the average error in the model's predictions over the last 2 months and, if the error is greater than 1.5%, assumes that the error will continue over the next several months, decreasing by 30% each month.

In forecasting ridership, weekend ridership should be considered as a constant unless there is a change in fares or operations that will clearly and significantly change weekend ridership. The analysis of weekend ridership showed that any model did an extremely poor job of predicting changes in ridership, so since we cannot accurately predict the impacts of small changes in fares or service, they should be ignored. However, a change such as eliminating the 25% weekend discount is a sufficiently large fare change that we can reliably predict that SCRRA will lose 10% to 20% of its weekend ridership. Furthermore, a change such as completely eliminating service on lines that currently carry about 50% of the weekend ridership can be reasonably predicted to result in the loss of those riders.

Annual Change in Average Fares Affecting Metrolink Boardings



Fiscal Year	Fare Changes (Percentages are system average)	Metrolink Boardings	Annual Percentage Change in Ridership
FY07	-	11,026,264	-
FY08	3.5%	11,519,486	4%
FY09	5.5%	11,796,086	2%
FY10	3.0%	10,774,390	-9%
FY11	6.0%	10,605,300	-2%
FY 12	0.0%	N/A	N/A

- In FY08 average fare increased by 3.5% and boardings went up by 4%.
- In FY09, average fares increased by 5.5% and boardings went up by 2%.
- In FY10 average fares increased by 3% and boardings went down by 9%.
- in FY11 average fares increased by 6% and boardings went down by 2%.

Boardings decreased significantly in FY10 although the fare increase was less than FY09 (3.5% Vs. 5.5%), which explains the impact of other factors, such as employment and/or price of gas on the boardings.