A Longitudinal Study of Bike Infrastructure Impact of Bike-share System Performance

NYU

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Motivation

A need for effective system-wide decision support tools for public agencies to determine amount and timing of bike infrastructure investments.

Research Problem

Longitudinal data

- Bike-share ridership (*Citi Bike*)
- Weather factors (i.e. temperature)
- Build environment factors (i.e. bike lane length)

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Time Series Model - Autoregressive Conditional Heteroscedasticity (ARCH)

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Measuring the marginal cost of building bike lanes/paths on bike share ridership

How to evaluate at a network-wide level (for NYC Citi Bike)?

Proposed Methodology

❑ Basic ARCH(1) model from Engle (1982,2001)

- Mean Equation: $y_t = \mathbf{x}_t\beta + e_t$
- Variance Equation: $h_t = \gamma + \alpha e_{t-1}^2$

where $\mathbf{x}_t\beta$: mean value of the time series with parameters β;e_t: error of the regression (normally distributed and heteroskedastic); h_t: variance of e_t (depends on the squared error in the preceding time period); α, γ: variance parameters

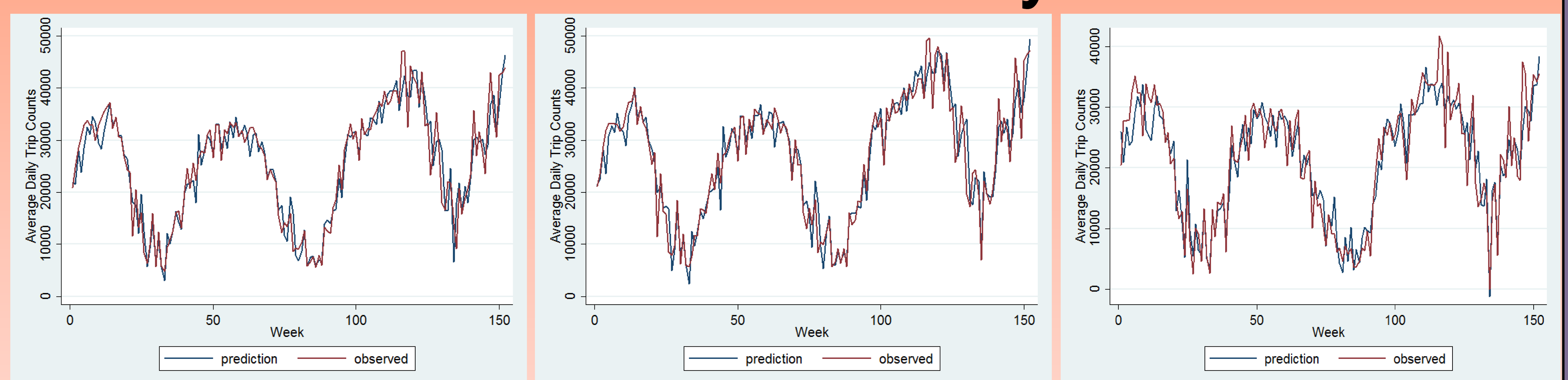
❑ We added AR disturbance following an ARCH process:

- $y_t = \mathbf{x}_t\beta + AR(y_t, p) + e_t$
- $AR(y_t, p) = c + \varepsilon_t + \sum_{i=1}^{p} \varphi_i y_{t-i}$
- $h_t = \gamma + \alpha_1 e_{t-1}^2 + \alpha_2 e_{t-2}^2$

where

y_t: dependent variable, in this case it is *Average Daily Trip Counts per Week;* $\mathbf{x}_t$: vector of independent variables; β: matrix of parameter coefficients; $AR(p)$: autoregressive disturbance with $p = 6$; e_t: error in the model; c: constant term; ε_t: error in AR; φ_i: coefficients in AR

Model Accuracy



Model 1
- each week's observation is based on average over the seven days
- NRMSD: 7.323 %

Model 2
- only average weekdays are included in each observation
- NRMSD: 7.475 %

Model 3
- only average over Saturday and Sunday are included in each observation
- NRMSD: 8.515 %

Model Estimation

ARCH family regression -- AR disturbances

Sample: 1 - 152 Number of observations = 152

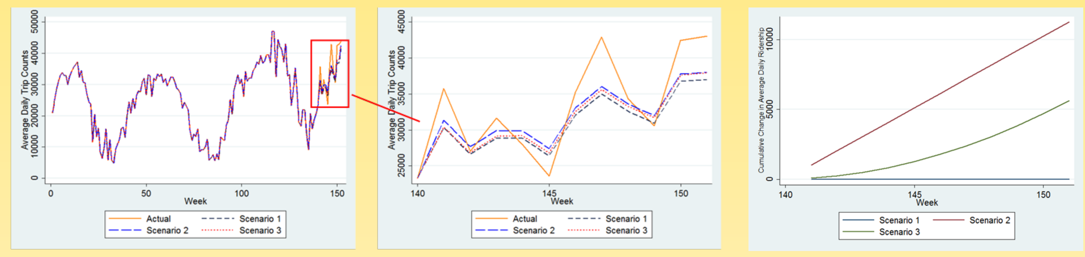
Distribution: Gaussian

	Model 1	Model 2	Model 3
Variable[1]	Coef.	Coef.	Coef.
avgdtc			
avgpp	-11319.170***	-10530.46***	-6055.377***
avgsd	-319.516*	-311.626*	-187.348
avgt	291.705***	284.868***	346.075***
avgws	-369.328**	-480.755***	-327.488*
bl	102.366*	134.833	81.185***
activesta	42.866*	69.824***	3.351
_cons	-68237.580*	-93222.400	-47823.060***
AR			
L1	0.768***	0.828***	0.441***
L2	0.137	0.133	0.192
L3	-0.102	-	0.090
L4	0.265***	-	0.147
L5	-0.052	-	0.047
L6	-0.112	-	-0.129
ARCH			
L1	0.166	-0.026	0.177
L2	0.738***	0.562***	0.042
_cons	2878262***	6469871***	9807573***

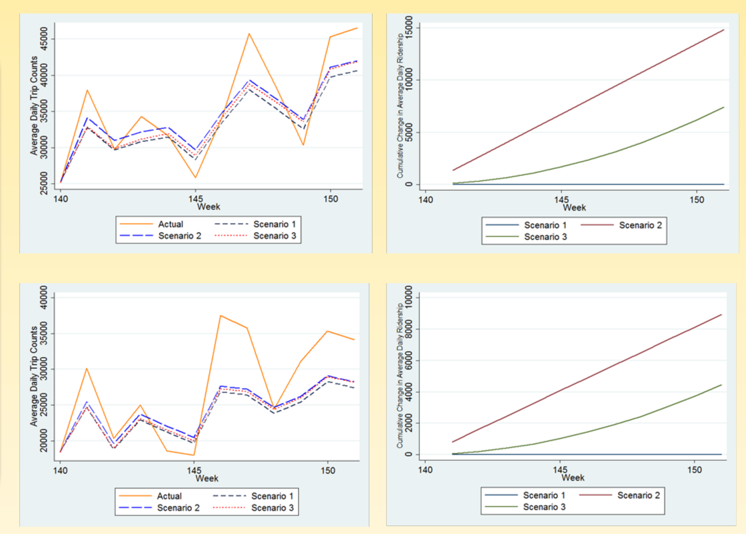
t statistics in parentheses: * p<0.05, ** p<0.01, *** p<0.001

1.avgdtc - average daily trip counts; avgpp - average precipitation (inch); avgsd - average snow depth (in); avgt - average temperature (F); avgws - average wind speed (mph); bl - total bike lane length (mile); activesta - average number of daily active stations

Scenario Analysis



A: future, 10% growth of active bike stations over time horizon, no infrastructure investment
B: future, 10% growth of active bike stations over time horizon, infrastructure investment as planned, but all in the beginning
C: future, 10% growth of active bike stations over time horizon, infrastructure investment as planned, but staged into additions every week



Starting from week 141, there is one greater exogenous shock in scenario 1, and smaller shock every week for scenario 2. At the end of the projection, the values are same in both scenario 1 and 2. The Same conclusion can be obtained from figure at right. Scenario 1 with no infrastructure investment is considered as baseline. One-time investment (Scenario 2) at the beginning is always the best without considering equipment or labor cost.

Conclusion and Future Work

- The time series regression analysis – ARCH with AR disturbance was applied to investigate the relationship between the Citi Bike daily trip counts and the total length of bike lane in NYC.
- There are about 100 Citi Bike daily average trips (per week) will be conducted with one additional mile of bike lane installed.
- New bike lanes have a positive impact on weekend (Saturday & Sunday) cyclist activity, and no significant impact on weekday.
- The series has annual seasonal cycles, and we only have limited three cycles. In future studies, we will update the model framework by adding more observed attributes.
- Another interesting research direction is to investigate the effect of bike lane coverage for Citi Bike member's route choice, which would require additional work.

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