

New York City Subway Ridership Time of Day Pattern



IN MEMORY OF
**IGNATIUS ADANGA
CHARLES LESPERANCE
SEE WONG SHUM**

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Outline

- Motivations and research questions
- Datasets
- Ridership spatial distribution
- Ridership temporal distribution
- Built environment and temporal distribution
- Conclusions and future work

Motivations and research questions

Motivations

- ✓ Ridership projection
- ✓ Transit operation
- ✓ Subway station planning

Research questions

- ✓ How is ridership spatially distributed?
- ✓ How is ridership temporally distributed?
- ✓ What factors contribute to ridership temporal distribution?

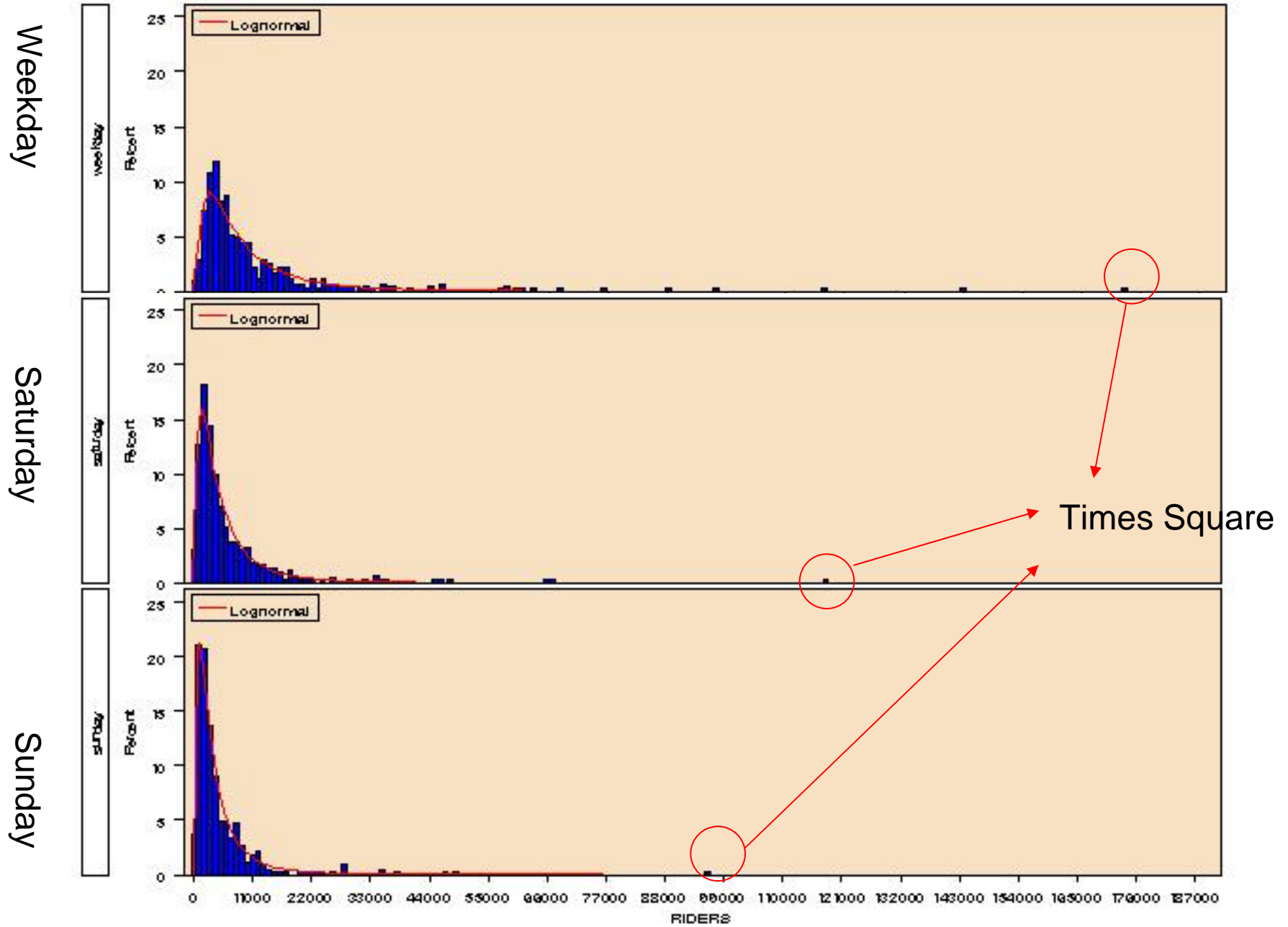
Datasets

- Ridership
- Transfer ridership (bus to subway)
- Subway station and bus station location
- New York City street map files.
- Land use
- SES. data
- Employment information
- General travel cost to three zones in CBD

Ridership spatial distribution

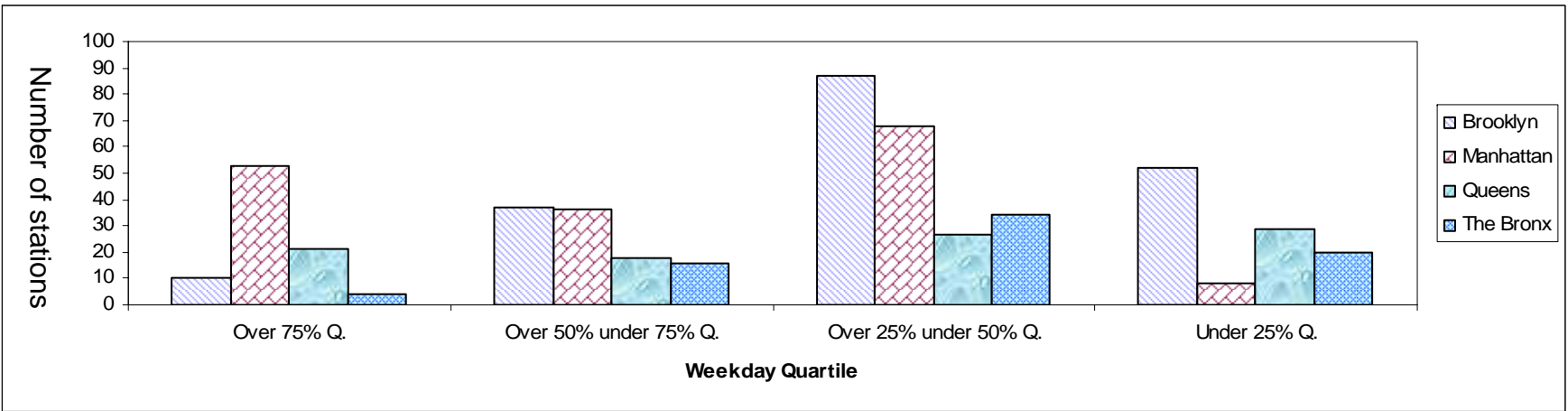


Ridership spatial distribution

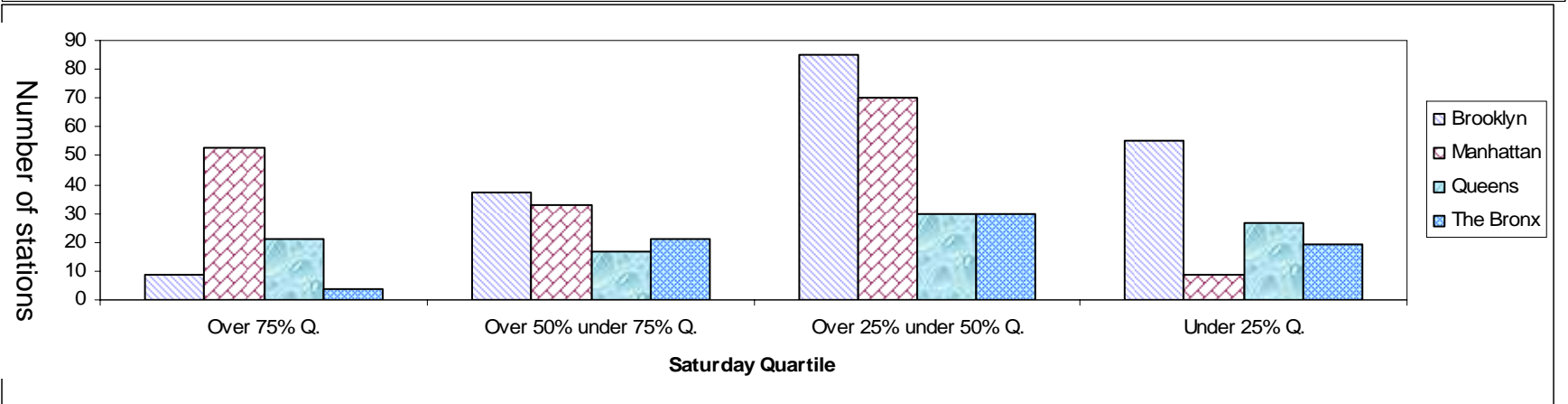


Ridership spatial distribution

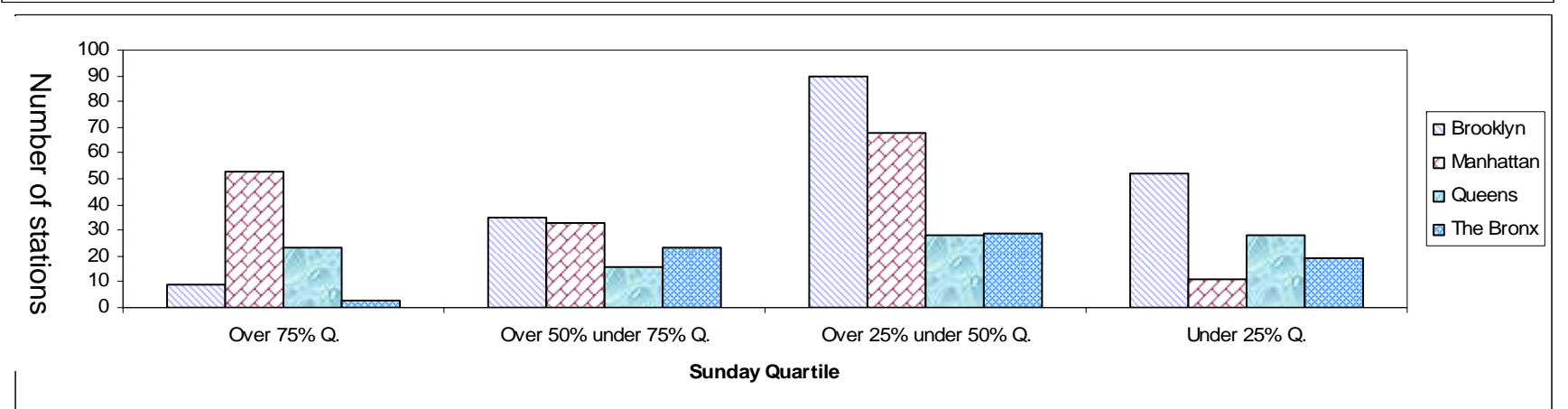
Weekday



Saturday

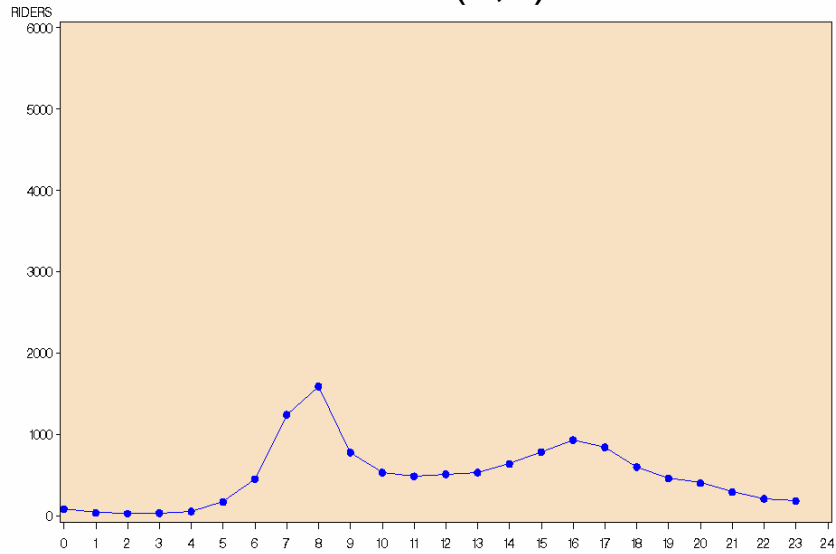


Sunday

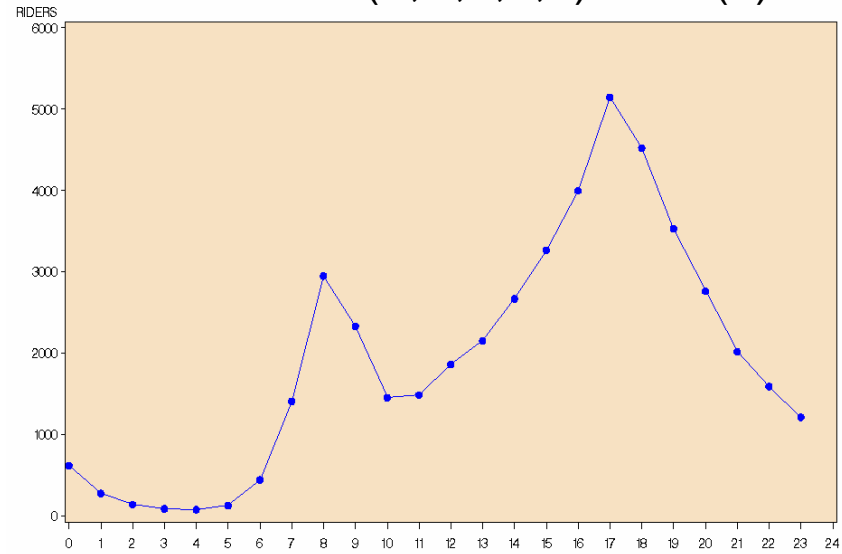


Randomly Selected Ridership Temporal Distribution

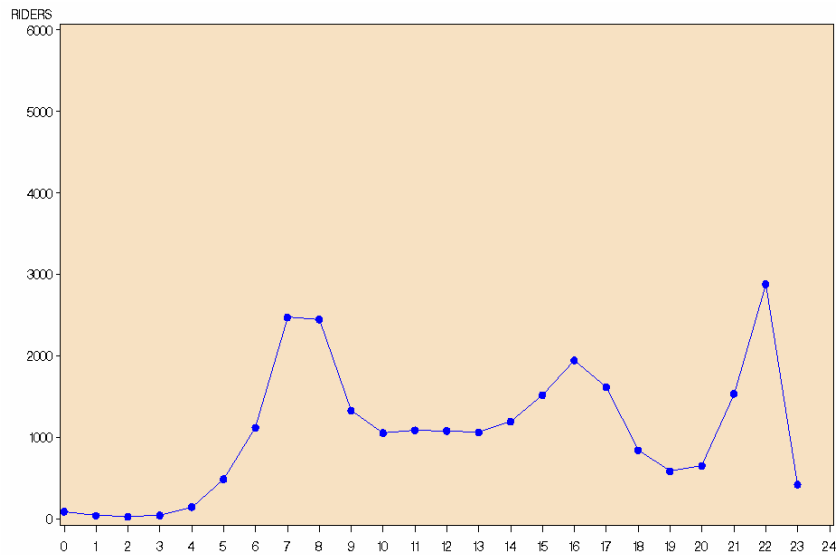
135 St (2,3)



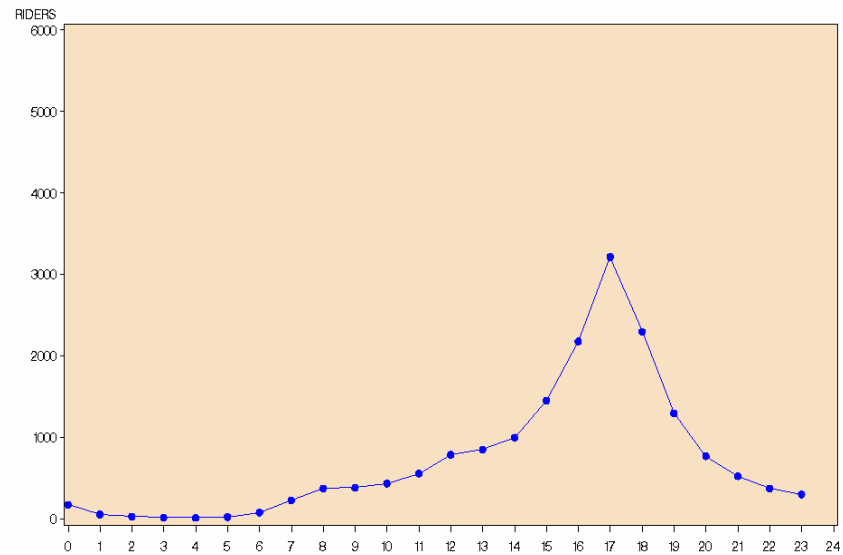
14 St (F,V,1,2,3)/6 Av (L)



161 St – Yankee Stadium (B,D,4)



Canal St (A,C,E)

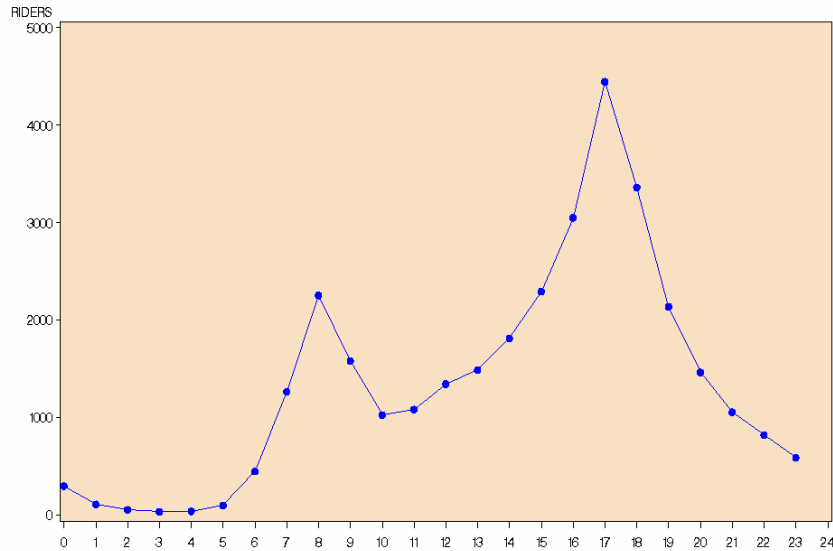


Ridership Temporal Distribution – Cluster analysis

- **Concentration of ridership**
 - Morning peak hourly ridership
 - Afternoon peak hourly ridership
 - Early morning hourly ridership
 - Midday hourly ridership
- **Transfer ridership ratio (bus to subway)**
 - Morning peak transfer ridership ratio
 - Afternoon peak transfer ridership ratio
 - Early morning transfer ridership ratio
 - Midday transfer ridership ratio
- **Position of Concentration in time**
 - Morning peak starting time
 - Morning peak duration
 - Afternoon peak starting time
 - Afternoon peak duration
- **Relative magnitude of ridership**
 - Ratio of morning peak hourly over total daily ridership
 - Ratio of afternoon peak hourly over total daily ridership
 - Ratio of early morning hourly over total daily ridership
 - Ratio of midday hourly over total daily ridership
 - Ratio of morning peak hourly over maximum hourly ridership
 - Ratio of early morning hourly over maximum hourly ridership
 - Ratio of midday hourly over maximum hourly ridership

Ridership Temporal Distribution – Cluster analysis

High Afternoon Peak Pattern

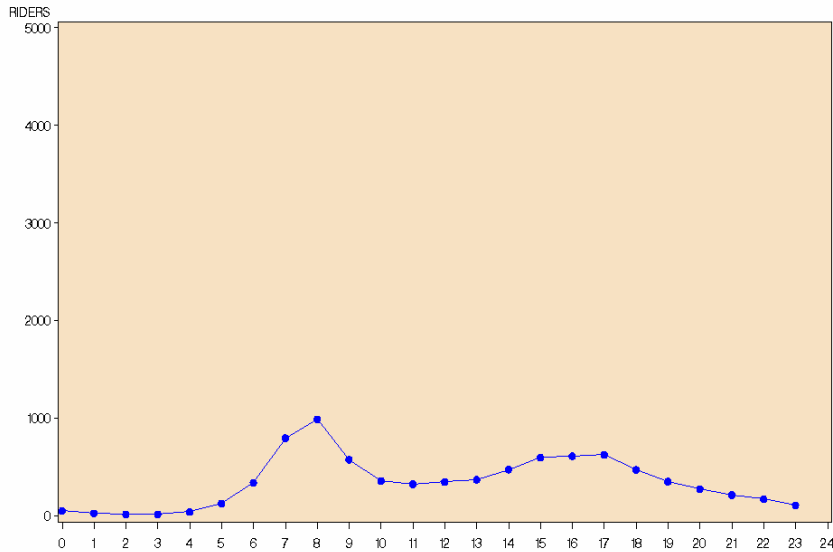


- 64 stations
- Total daily: 32,137
- Morning peak hourly riders: 2,309
- Afternoon peak hourly riders: 4,514
- Early morning hourly riders: 315
- Midday hourly riders: 1,707
- A.M. peak starting time: 8:12 am.
- A.M. peak duration: 62 minutes.
- P.M. peak starting time: 4:53 pm.
- P.M. peak duration: 77 minutes.

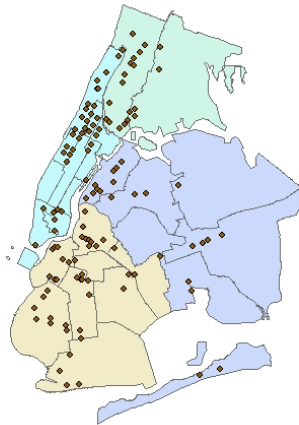


Ridership Temporal Distribution – Cluster analysis

High Morning Peak Pattern

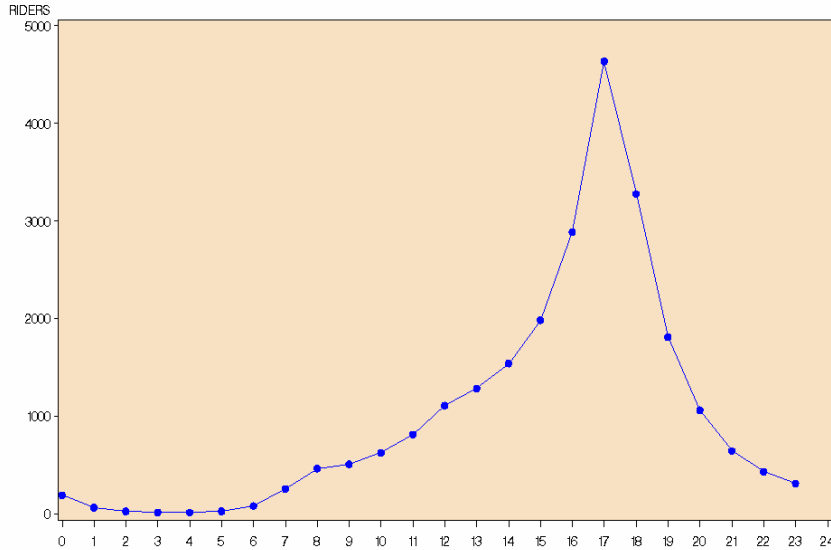


- 123 stations
- Total daily: 8,196
- Morning peak hourly riders: 1,068
- Afternoon peak hourly riders: 707
- Early morning hourly riders: 143
- Midday hourly ridership: 447
- A.M. peak starting time: 7:40 am.
- A.M. peak duration: 61 minutes
- P.M. peak starting time: 4:10 pm.
- P.M. peak duration: 82 minutes



Ridership Temporal Distribution – Cluster analysis

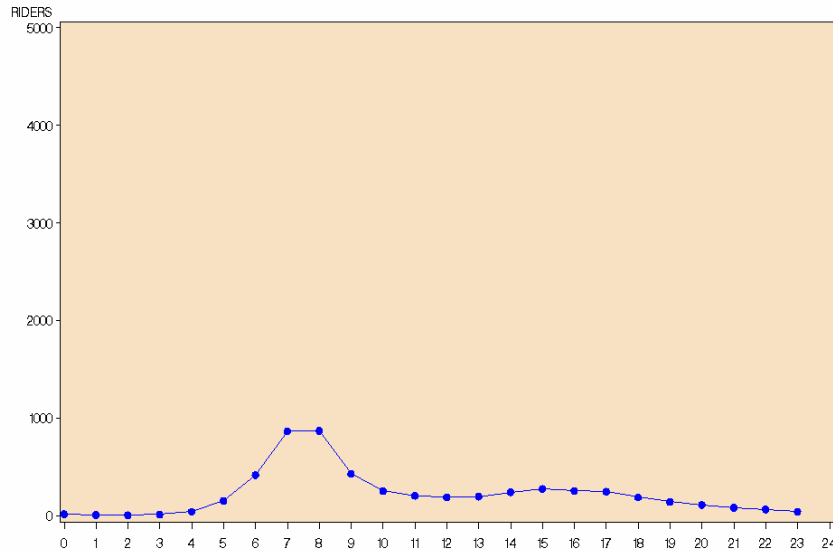
No Morning Peak Pattern



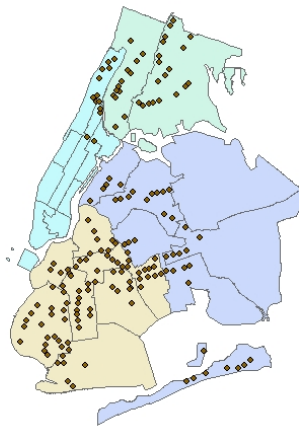
- 12 stations
- Total daily: 24,061
- Morning peak hourly riders: **no morning peak**
- Afternoon peak hourly riders: **4,961**
- Early morning hourly riders: 164
- Midday hourly riders: 1,461
- A.M. peak starting time: ~
- A.M. peak duration: ~
- P.M. peak starting time: 4:52pm.
- P.M. peak duration: **68** minutes

Ridership Temporal Distribution – Cluster analysis

Low Ridership Pattern

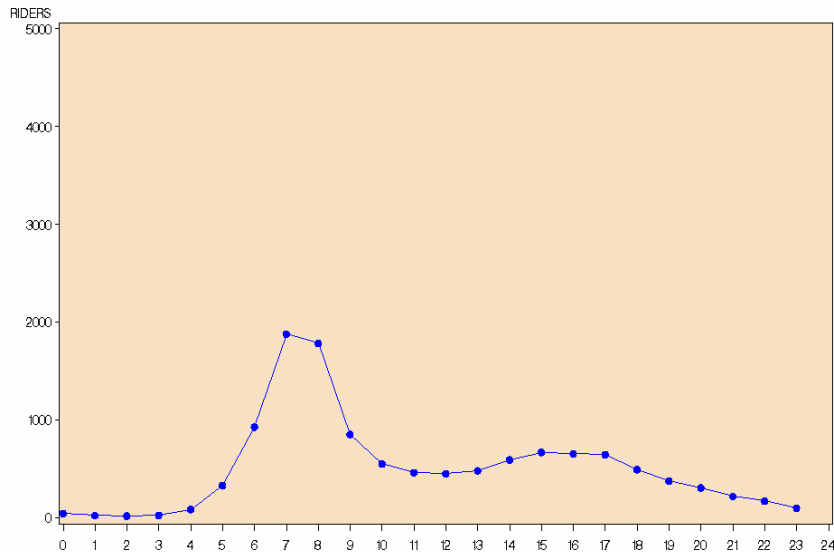


- 167 stations
- Total daily: 5,294
- Morning peak hourly riders: 1,024
- Afternoon peak hourly riders: 297
- Early morning hourly riders: 137
- Midday hourly riders: 280
- A.M. peak starting time: 7:26 am.
- A.M. peak duration: 62 minutes
- P.M. peak starting time: 3:39 pm.
- P.M. peak duration: 97 minutes

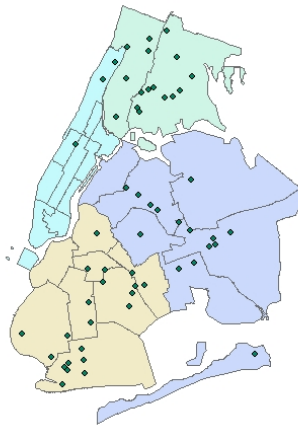


Ridership Temporal Distribution – Cluster analysis

High Transfer Pattern



- 57 stations
- Total daily: 12,100
- Morning peak hourly ridership: 2,113
- Afternoon peak hourly ridership: 724
- Early morning hourly ridership: 298
- Midday hourly ridership: 629
- A.M. peak starting time: 7:25 am.
- A.M. peak duration: 63 minutes
- P.M. peak starting time: 3:47pm.
- P.M. peak duration: 97 minutes
- Transfer ridership (>25%)



Ridership Temporal Distribution – Pattern Statistic

<i>Patterns</i>	High Afternoon peak	High Morning peak	No Morning peak	Low Ridership	High Transfer
Number of stations	64	123	12	167	57
<i>Total Volume</i>					
Total daily ridership	32,137	8,196	24,061	5,294	12,100
<i>Concentration of the Volume</i>					
Morning peak dummy (whether there is peak or not)	1	1	0	1	1
Afternoon peak dummy (whether there is peak or not)	1	1	1	1	1
Morning peak ridership volume (average)	2,331	1,076	0	1,058	2,211
Morning peak hourly ridership (average)	2,309	1,068	625	1,024	2,113
Ratio of morning peak hourly over total daily	0.06	0.13	0.03	0.20	0.18
Afternoon peak ridership volume (average)	5,823	1,019	5,086	490	1,284
Afternoon peak hourly ridership (average)	4,514	707	4,691	297	724
Early morning hourly ridership (average)	315	143	164	137	298
Midday hourly ridership (average)	1,707	447	1,461	280	629
Ratio of afternoon peak hourly over total daily	0.15	0.09	0.18	0.06	0.06
Ratio of morning peak hourly over afternoon peak hourly	0.49	1.66	0.18	3.78	3.00
Ratio of early morning hourly over daily hourly	0.21	0.44	0.17	0.65	0.59
Ratio of early morning hourly over maximum peak hourly	0.06	0.13	0.04	0.14	0.14
Ratio of midday hourly ridership over daily hourly	1.30	1.33	1.55	1.26	1.24
Ratio of midday hourly ridership over maximum peak hourly	0.37	0.41	0.39	0.27	0.31

Ridership Temporal Distribution – Pattern Statistic

<i>Patterns</i>	High Afternoon peak	High Morning peak	No Morning peak	Low Ridership	High Transfer
<i>Transfer Ridership</i>					
Ratio of morning peak transfer ridership over morning peak hourly ridership	0.05	0.07	0.02	0.04	0.25
Ratio of afternoon peak transfer ridership over afternoon peak hourly ridership	0.02	0.06	0.01	0.05	0.24
Ratio of early morning transfer ridership over early morning hourly ridership	0.07	0.10	0.04	0.05	0.38
Ratio of midday transfer ridership over midday hourly ridership	0.03	0.06	0.01	0.04	0.25
<i>Position of the Concentration</i>					
Morning peak starting time (am.)	8:12	7:40	~	7:26	7:25
Afternoon peak starting time (pm.)	4:53	4:10	4:52	3:39	3:47
Morning peak duration (minutes)	62	61	0.00	62	63
Afternoon peak duration (minutes)	77	82	68	97	97

Built environment and temporal distribution

- Discrete choice analysis
- Dependent variables: five identified patterns
- Independent variables:
 - Local features (within 500 meters radius)
 - ✓ Socio-economic and demographic
 - ✓ Land use
 - ✓ Employment
 - ✓ Street density
 - ✓ Bus station density
 - General travel cost to three zones in CBD

Built environment and temporal distribution :
Location Statistic associated with each pattern

Patterns	High Afternoon peak	High Morning peak	No Morning peak	Low Ridership	High Transfer
Number of Stations	64	123	12	167	57
<i>S.E.D.</i>	mean	mean	mean	mean	mean
Population	15516	17562	7512	16260	13684
Household	8515	6817	3936	5693	4868
White alone (%)	73	40	73	34	34
Black & African American (%)	6	25	7	30	28
Asian alone (%)	14	8	13	8	11
Two races or more (%)	3	6	3	6	6
Non-Hispanic (%)	90	63	91	61	63
Hispanic (%)	10	37	9	39	37
Median income	68359	34452	70314	32369	32872

Built environment and temporal distribution :
 Location Statistic associated with each pattern

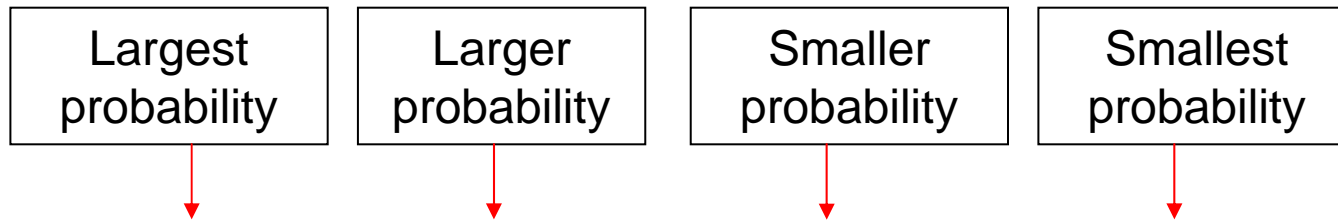
Patterns	High Afternoon peak	High Morning peak	No Morning peak	Low Ridership	High Transfer
<i>Transportation</i>	mean	mean	mean	mean	mean
Number of bus stops	43	27	49	21	26
Number of express bus stops	16	1	23	1	2
Distance to downtown	7	12	7	14	15
Distance to midtown	7	11	7	14	14
Distance to valley	7	12	7	13	14
<i>Land use and employment</i>					
Total employment	71020	6026	86172	2553	3329
Percentage of commercial floor area (%)	74	33	87	17	27
Percentage of residential floor area (%)	26	67	13	83	73

Built environment and temporal distribution

Patterns and associated features

- High Afternoon Peak Pattern – Land use mixed zones, high commercial land use percentage
- High Morning Peak Pattern – Land use mixed zones, medium commercial land use percentage
- No Morning Peak Pattern – Highly commercial zones
- Low Ridership Pattern – Highly residential zones mostly outside Manhattan
- High Transfer Pattern – Highly residential zones and subway service boundary

Influence of independent variables on Patterns



- Population + Employment:
High PM Peak -> No AM Peak -> High AM Peak-> Low Riders and High Transfer
- Percentage of white population:
No AM Peak -> High PM Peak -> High AM Peak-> Low Riders and High Transfer
- Percentage of Asian population:
No AM Peak -> Low Riders and High Transfer -> High PM Peak -> High AM Peak
- Commercial floor area:
No AM Peak -> High PM Peak -> High AM Peak-> Low Riders and High Transfer
- Distance to midtown:
Low Riders and High Transfer -> High AM Peak-> High PM Peak -> No AM Peak
- Percentage of residential floor area:
Low Riders and High Transfer -> High AM Peak-> High PM Peak -> No AM Peak

Conclusions

- Few has looked at time of day aspects, ours is one of the first
- Developed methodologies to characterize time of day pattern
- Demonstrated that:
 - Ridership time of day patterns vary by station
 - Distinctive time of day patterns can be identified
 - Local land use and station position in the transit network are both important factors in determining pattern membership

Next Steps

- Identify how the time of day attributes are related with each other
- Understand differences between weekdays and weekends
- Understand the change in patterns over time
- Linking station level analysis to metro-card level analysis

Acknowledgement

NYMTC

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