Using GIS to analyze Spatial and Temporal Trip Patterns and Location of MetroLift Patrons in Harris County, Texas

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Using GIS to analyze Spatial and Temporal Trip Patterns and Location of MetroLift users in Harris County

Why do the analysis?

- Senior/Disabled population is expected to increase in Harris County and surrounding areas- expected increase in MetroLift demand
- Funds are limited- No major increase in Budget since 2009
- Metrolift needs to use its resources wisely
- This analysis can help Metrolift optimize their services by better understanding their customers and their trip behaviors in Harris County
- GIS is an ideal tool to perform the analysis
  - Adds the spatial component along with other analytical capabilities
  - Helps to visualize the problem spatially
  - Provides spatial statistical tool along with modeling
Presentation Content

- Basic facts about MetroLift - Data Source

- Analysis 1: Spatial Pattern Analysis of the MetroLift Patrons
  - Where do Metro lift users reside? Do block group characteristics reflect the demand of MetroLift?

- Analysis 2: Temporal Pattern analysis of trips based on Activity type of the MetroLift users using the data of October 2013
  - When and how many trips are being made?
  - What types of trips are being made?
  - When are these different trips being made?

- Analysis 3: Spatial Analysis of trips based on the activity and frequency
  - Where are the trips going?

- Conclusion and Future Direction
**MetroLift Basic**

**What is MetroLift? Who is Eligible?**

- Complementary paratransit service by the Metropolitan Transit Authority - in compliance with 1990 Americans with Disabilities Act

- Healthcare professionals certificate required - METRO makes the final eligibility decision

- Provides transportation for persons with disabilities who cannot access fixed route due to limitations preventing them from walking or rolling to a bus stop

- Vehicles Types - 118 First Transit & 200 Yellow Cab: Other Service Modes: Taxicab Backup & MetroLift Subsidy Program (MSP)

- Hours of Operation - 7 days a week from 3:45 am to Last Trip Originating at 1:30 am

- Fare: Single ticket - $1.15; 10-ride book - $9.75; Monthly Pass - $38.60; Annual Pass - $347.00

- Total Eligible Patrons (as of Dec 2013) = 16,974: Average Trips per weekday = 5000+

Source: Presentation by Art Jackson, Senior Director; METROLift Serving the People of Houston, APTA Conference, Memphis, Tennessee, May 25, 2011
MetroLift Basic

MetroLift Service Area

Service Area-751 sq. miles
Data Sources

- **METRO-Lift division**
  - Trips - Combined total pickup and/or drop-off trip data for October 2013
  - List of customer addresses for December 2013
  - Entire MetroLift Service Area

- **Houston Galveston Area Council (HGAC)**
  - 2010 Parcel Data with Land use classification
  - Major Roads, City Boundary, Hospitals, Schools, Grocery Stores, Water features and Boundaries

- **Census.gov/acs (2008-2012)**
  - Several Block Group data - American Community Survey 2008-2012
Analysis 1: Spatial Pattern Analysis
The Residential Location of MetroLift Patrons

- Total Metrolift Users based on Dec 2013: 16,973
- Users inside Harris County: 16,500
- Users inside Harris County and MetroLift Service Area: 15,906
Analysis 1: Spatial Pattern Analysis
Percentage of Metrolift Users at the Block Group Level

11 out of 1684 Block Groups have > 5% Metrolift Users
Analysis 1: Spatial Pattern Analysis
Characteristics of those Block Groups with Highest percentage of Metrolift Users

<table>
<thead>
<tr>
<th>MetroLift Users (% of BG pop.)</th>
<th>Zip Code</th>
<th>Total Households</th>
<th>Total Population</th>
<th>% Disable over 18 years</th>
<th>% Male over 50 years</th>
<th>% Female over 50 years</th>
<th>% White</th>
<th>% Black</th>
<th>% Household Income below Poverty level</th>
<th>% Household Without Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.70</td>
<td>77091</td>
<td>242</td>
<td>343</td>
<td>45.19</td>
<td>9.62</td>
<td>58.31</td>
<td>50.15</td>
<td>37.61</td>
<td>34.30</td>
<td>75.21</td>
</tr>
<tr>
<td>14.29</td>
<td>77019</td>
<td>10</td>
<td>168</td>
<td>83.33</td>
<td>29.76</td>
<td>26.79</td>
<td>76.79</td>
<td>14.88</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>13.18</td>
<td>77022</td>
<td>806</td>
<td>1426</td>
<td>40.04</td>
<td>29.10</td>
<td>28.12</td>
<td>79.52</td>
<td>19.07</td>
<td>31.39</td>
<td>61.54</td>
</tr>
</tbody>
</table>

- **Block Groups with Highest percentage of Metrolift Users**
  - High percentage of Disabled over 18 years
  - High percentage of household without vehicles

- **Based on the information from Metrolift**
  - 79% of users are 50 years and over
  - 70% female responded to the customer satisfaction survey
Analysis 1: Spatial Pattern Analysis
Do block group characteristics reflect the demand for MetroLift?

Methods used for Analysis

- Geocoded the Residential addresses - Only selected the Residences inside Metrolift Service Area in Harris County
- Used Spatial Join to combine the Geocoded results with Block Group data of Harris county to obtain the Number of Residences by Block Group
- Based on the data availability at Block Group level for ACS 2008-2012 - Joined several Block Group Data to use as Explanatory variables
- Used Exploratory Regression and Ordinary Least Square (OLS) Regression data to explore the relationship between percentage of metroflit users and block group characteristics
Analysis 1: Spatial Pattern Analysis
Exploratory Regression: What are different Block Group characteristics related to MetroLift Demand?

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Exploratory Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of MetroLift Residences (Number of MetroLift Users per Block Group/Total Population of Block Group (BG))</td>
<td>Disability</td>
</tr>
<tr>
<td>- + Percent of Disable Population 18 years and over</td>
<td>+ Percent of Householder between 45 to 64 years that has income below poverty level in past 12 months</td>
</tr>
<tr>
<td>- Percent of Disable Population 65 years and over</td>
<td>+ Percent of Householder 65 and over that has income below poverty level in past 12 months</td>
</tr>
<tr>
<td>- Percent of Male Disabled and unemployed population between 16 to 64 years</td>
<td></td>
</tr>
<tr>
<td>- Percent of Female Disabled and unemployed population between 16 to 64 years</td>
<td></td>
</tr>
<tr>
<td>- Percent of Female Disabled and employed population between 16 to 64 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Highlighted Variables are significant - P - Value < 0.05
Analysis 1: Spatial Pattern Analysis
Ordinary Least Square Regression (OLS) for the significant variables

1. **OLS Equation**
   \[% \text{Metrolift Users} = \% \text{Disable 18yrs \& over} + \% \text{Black} + \% \text{Householder 65 years over \& below poverty Level} + \% \text{Household without vehicle}\]

2. **Key Results**
   - Adjusted R-Square around 50%
   - Significant Koenker statistic 
   - Significant Jarque-Bera statistic 
   - Relationship is non-stationary
   - Result can be improved by using some spatial regression
   - Residue is not normally distributed

* Indicate p-value < 0.05

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**OLS Diagnostics**

<table>
<thead>
<tr>
<th>Input Features:</th>
<th>RegressionDataResidence</th>
<th>PCTRESIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Observations:</td>
<td>1463</td>
<td>-9965.891982</td>
</tr>
<tr>
<td>Multiple R-Squared [d]:</td>
<td>0.505912</td>
<td>0.503535</td>
</tr>
<tr>
<td>Joint F-Statistic [e]:</td>
<td>212.831502</td>
<td>0.000000*</td>
</tr>
<tr>
<td>Joint Wald Statistic [e]:</td>
<td>741.449697</td>
<td>0.000000*</td>
</tr>
<tr>
<td>Koenker (BP) Statistic [f]:</td>
<td>189.267168</td>
<td>0.000000*</td>
</tr>
<tr>
<td>Jarque-Bera Statistic [g]:</td>
<td>763196.150869</td>
<td>0.000000*</td>
</tr>
</tbody>
</table>

Notes on Interpretation

* An asterisk next to a number indicates a statistically significant p-value (p < 0.05).
Analysis 1: Spatial Pattern Analysis
Analysis of OLS Results

3. Analysis of Results

- **Spatial Autocorrelation of Residue** - statistically significant
- **Hot Spot Analysis on Regression Residue (BGL):**
  - Red area - over performance
  - Blue area - under performance

**Regression Model:**
\[
\% \text{ Metrolift Users} = \% \text{ Disable 18 yrs & over} + \% \text{ Black} + \% \text{ Householder 65 years over & below poverty Level} + \% \text{ Household without vehicle}
\]
**Future steps for Analysis 1**

- Explore other spatial models - such as Geographically Weighted Regression (GWR)
- Identify additional significant variables from additional analysis

**Analysis 2:** Temporal Pattern analysis of trips based on Activity type of the MetroLift users using the data of October 2013

- When and how many trips are being made?
- What types of trips are being made?
- When are these different Activity Trips being made?

**Analysis 3:** Spatial Analysis of trips based on the activity and frequency

- Where are the trips going?
Analysis 2: Temporal Trip Pattern Analysis of the MetroLift Patrons

When and how many trips are being made?

**Number of Trips By Day**

Total Trips = 237,869

- **Peak Day for the Trips**
  - Tuesdays, Wednesdays and Thursdays are peak days for the trips

- **Peak Period for Seven days**
  - **Weekdays Peak Period:** 8-9 am and 3-4 pm
  - **Saturday:** 10-11 am & 1-2 pm
  - **Sunday:** 10-11 am & 1-2 pm
Analysis 2: Temporal Trip Pattern Analysis on Activity Type

What types of trips are being made?

Number of Trips by Activity Type

Methods used for Analysis
- Geocoded the trip addresses - Created 50 feet Buffer
- Spatial Join the Buffer with the Parcel data
- Based on the land use code of the parcel, Activity types were classified
- Used Summary Statistic and Pivot table to obtain a table that have frequency of the trips by Activity type, Time of a day and Day of a week - Graphed the results
### Analysis 2: Trip Pattern Analysis by Days of the Week

**When are these different Activity Trips being made?**

<table>
<thead>
<tr>
<th>Day</th>
<th>Education</th>
<th>Medical</th>
<th>Religious</th>
<th>Shopping</th>
<th>Work</th>
<th>Residential</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>1034</td>
<td>965</td>
<td>1173</td>
<td>12212</td>
<td>3403</td>
<td>14172</td>
<td>680</td>
</tr>
<tr>
<td>Tuesday</td>
<td>1523</td>
<td>1310</td>
<td>1544</td>
<td>16471</td>
<td>4507</td>
<td>19632</td>
<td>942</td>
</tr>
<tr>
<td>Wednesday</td>
<td>1472</td>
<td>1278</td>
<td><strong>2014</strong></td>
<td><strong>17041</strong></td>
<td>4572</td>
<td><strong>20599</strong></td>
<td>998</td>
</tr>
<tr>
<td>Thursday</td>
<td>1460</td>
<td>1170</td>
<td>1362</td>
<td>15838</td>
<td>4327</td>
<td>18935</td>
<td>861</td>
</tr>
<tr>
<td>Friday</td>
<td>1016</td>
<td>921</td>
<td>1031</td>
<td>13239</td>
<td>3533</td>
<td>15433</td>
<td>737</td>
</tr>
<tr>
<td>Saturday</td>
<td>340</td>
<td>128</td>
<td>741</td>
<td>6304</td>
<td>1050</td>
<td>6411</td>
<td>369</td>
</tr>
<tr>
<td>Sunday</td>
<td>266</td>
<td>59</td>
<td>1430</td>
<td>3575</td>
<td>607</td>
<td>5322</td>
<td>234</td>
</tr>
<tr>
<td><strong>Total trips</strong></td>
<td><strong>7111</strong></td>
<td><strong>5831</strong></td>
<td><strong>9295</strong></td>
<td><strong>84680</strong></td>
<td><strong>21999</strong></td>
<td><strong>100504</strong></td>
<td><strong>4821</strong></td>
</tr>
</tbody>
</table>

- **Highest Number of Education and Medical trips** - Tuesday
- **For all other Activity Types** - Peak day is Wednesday
At What times are these different Activity Trips being made?

Peak Time varies by trip type

- **Education Trips**: 8-9 am
- **Medical Trips**: 12pm -1pm
- **Religious Trips**: 9-10am
- **Shopping Trips**: 2 pm - 3 pm
  - No distinct peak
- **Work Trips**: 3 - 4pm
  - distinct peak
- **Residential Trips**: 7-8 am and 4-5 pm
  - distinct peak
- **Leisure Trips**: 8-9 am and 1-2 pm
  - less distinct peak
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Next question is: **Where are the trips going?**

Methods used for Analysis

- Geocoded trips - Buffer - Spatial Join with Parcel data
- Based on the land use code of the parcel, Activity types were classified
- Used Summary Statistics and Frequency Tools to create feature class that has the attributes which include location of the trips, and the frequency of each activity
- Used Field Calculator to calculate Concentration (%) of trips - \( \frac{\text{Frequency of trips in the location}}{\text{total number of trips in that category}} \)
- Using Symbology - mapped the location of different activities
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Education Trips

- 7111 trips
- 264 Activity Locations
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Medical Trips

- 5831 trips
- 70 Activity Locations
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Religious Trips

- 9259 trips
- 542 Activity Locations
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Shopping Trips

- 84680 trips
- 3893 Activity Locations
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Work Trips

- 21999 trips
- 428 Activity Locations
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Residential Trips

% Residential Trips
- Upto 0.5%
- From 0.5% to 1%
- Over 1%

101044 trips
5908 Activity Locations
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Leisure Trips

- 4821 trips
- 183 Activity Locations
Conclusions

Analysis 1 helps to understand the characteristic of MetroLift Users and demand for Metrolift services based on Block Group Characteristics

- Key variables: Number of Disabled Persons, Household Income, Race, and Vehicle Availability of Households

*Can be helpful in making decisions regarding expanding or contracting Service Area*

Analysis 2 helps to understand users’ trip behavior

- Tuesdays and Wednesdays are the peak days for all types of trips
- Peak periods for all trips: 8-9 am and 3-4 pm; Peak times and number of trips vary by the activity type and the day of the week
- Maximum trips are residential followed by Shopping and Work related trips

*Can be helpful in managing infrastructure decisions- number of drivers and vehicles based on peak days and periods*

Analysis 3 helps to visualize the location and concentration of trips

- Distribution of Shopping trips are near Grocery and Drug stores
- Residential Trips are related to the location of residences of Metrolift Users

*Can be helpful in innovative solutions like teaming with Big Box Grocery stores for home delivery of groceries, combining and chaining trips*
Limitations and Future Directions

**Limitations**

- Data did not have directional components - no way of knowing the origin and destination of trips
- Geocoding addresses place the points on the streets not inside the parcel - makes it difficult to identify the related parcel
- Trip data was available for only October 2013 while land use data used was for 2010

**Future steps**

- Get hold of additional and current data for Trips, Residences of Metrolift Users, relevant parcels and block group data
- Rerun analysis for at least 3 months
- Further analyze the findings - i.e. Why Wednesdays are Peak days?
- Continue working on Model to establish relationship between Metrolift Demand and additional block group Characteristic - Explore variables such as the type of disability, sidewalk conditions, distance to grocery stores etc.
- Complete paper for publication
THANK YOU

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