BERKSHIRE FLYER
MARKET RESEARCH REPORT

RESPECTFULLY SUBMITTED TO THE BERKSHIRE FLYER WORKING GROUP
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BY

The Students of MATH-444 Operations Research

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I. Background

A. The Berkshire Flyer Working Group (BFWG)

The Berkshire Flyer Working Group was established to study seasonal passenger rail service between New York City and Pittsfield, Massachusetts. This ongoing effort was inspired by the successful CapeFlyer, a weekend service between Boston and Cape Cod that operates from Memorial Day to Labor Day. Operated jointly by the Cape Cod Regional Transit Authority (CCRTA), the Massachusetts Bay Transportation Authority (MBTA), and Massachusetts Department of Transportation (MassDOT), the CapeFlyer carried 13,663 passengers across 15 weeks of service in 2016, earning approximately $230,000 in revenue that year [1]. Like the CapeFlyer, the proposed Berkshire Flyer service would be seasonal, running on weekends during the summer.

Legislation leading to the formation of the Berkshire Flyer Working Group (BFWG) was sponsored by Massachusetts state Senator Adam Hinds, D-Pittsfield, as part of the fiscal year 2018 (FY18) budget [2]. Regarding the proposed service, Hinds said in a statement that "transportation improvements are critical for the economic development of the region and the Commonwealth. NYC/Berkshire Rail would be an economic boon for our communities, cultural attractions, stores, restaurants and lodging."

In addition to Senator Hinds, the Working Group includes Astrid Glynn, Rail and Transit Administrator at MassDOT, Representative Tricia Farley-Bouvier, D-Pittsfield, Billy Keane of the Berkshire County Board of Realtors, Michael Kapnik, director Western Massachusetts Office of the Governor, Matthew Russett, community outreach coordinator for U.S. Rep. Richard Neal D-Springfield, Clete Kus, transportation program manager, Berkshire Regional Planning Commission, Elliot Sperling, transportation planner at MassDOT, Nathaniel Karns, executive director, Berkshire Regional Planning Commission, Francisca Heming, district 1 highway director at MassDOT, Lenox, Jonathan Butler, president and CEO, 1Berkshire, Eddie Sporn, Robin Road Consulting, Jay Green, Berkshire Scenic Railway, Robert Malnati, administrator, Berkshire Regional Transit Authority, Deanna Ruffer, director of community development, City of Pittsfield, and Alfred "A.J." Enchill, district aide to Senator Hinds.

Intended to attract tourism to Berkshire County from New York City, the Berkshire Flyer service may also help to address concerns about population decline in the Berkshires. According to Hinds, "When you look at our population in the Berkshires there's that 20 to 30 year-old gap and folks who might want to start a family here and take advantage of the cost of living and quality of living but wanting to maintain a connection to other economic center, in this case namely New York City."

B. The Berkshire Flyer Operations Research Group (BFOR)

The Berkshire Flyer Operations Research (BFOR) group is comprised of the eight undergraduate students enrolled in Dr. Erin Kiley’s MATH-444 (Operations Research) course at the Massachusetts College of Liberal Arts. The BFOR group was created to fulfill the
requirements of a course project designed to assist the BFWG in carrying out an initial pilot study on the proposed Berkshire Flyer service.

The BFOR Group sought to provide quantitative support to the BFWG’s objective, which, according to MassDOT representative Astrid Glynn, is “to find facts about potential ridership on a line that would use existing passenger rail track up New York state, then would cross into Massachusetts at West Stockbridge.” [3] Details regarding the proposed service are discussed in greater depth in Section II.

The BFOR group conducted its research in three phases:

1. E-mailed lodging and attractions lists provided by the Berkshire Flyer Working Group; in addition, reviewed bus ridership (Berkshire Regional Transport Authority).
2. Created a survey to be disseminated by participating businesses (lodgings and attractions). The survey is intended to reach potential riders, and requested that the survey be posted on the social media accounts of various establishments in the Berkshires.
3. Analyzed the survey results, synthesized findings in a report submitted to the Berkshire Flyer Working Group.

The BFOR group has a personal investment in the establishment of the proposed service; at least one of its members lived and worked in New York City while regularly commuting to the Berkshires, as have many of their family and friends. They can personally attest to the appeal of more convenient rail service between New York City and Berkshire county for travelers coming from either location. Indeed, they’re hopeful that future service will consider younger individuals who may want to settle in the Berkshires while maintaining economic ties with New York City.

II. The Proposed Service: Routes and Trackage

Two potential routes have been identified for the proposed Berkshire Flyer service. “Route 1” would go from Pittsfield to Albany-Rensselaer to New York City utilizing only existing track and Amtrak service. “Route 2” would go from Pittsfield to Castleton-on-Hudson (part of Schodack, NY) to New York City, bypassing Albany-Rensselaer and requiring 3,060 feet of new connection track as well as the use of 11 miles of CSX-owned track for which there is no existing Amtrak-CSX agreement. A third option involves increasing the frequency of service between Albany-Rensselaer and Pittsfield to align with existing service between New York Penn Station and Albany-Rensselaer.
Both proposed routes for new service would utilize at least part of the Empire Corridor South (Fig. 1), a 142-mile line which runs from New York Penn Station through the Hudson Valley to approximately one mile north of Albany-Rensselaer station. This includes Amtrak’s Empire Connection, a 10.8-mile portion of the West Side Line from Penn Station to the Spuyten-Duyvil bridge (connecting Manhattan to the Bronx neighborhood of Spuyten-Duyvil); here, track joins the Metro-North Railroad Hudson Line (owned and operated by the Metropolitan Transportation Authority) which runs from Spuyten-Duyvil to Poughkeepsie, NY.
The southern portion of the Hudson Line is a section from Spuyten-Duyvil to Croton-Harmon (21.4 miles), while the double-tracked northern portion runs from Croton-Harmon to Poughkeepsie (40.3 miles). Maximum speeds along the northern portion of the Metro-North Hudson Line range from 60-90 mph (60-70 mph due to curvature just north of Croton-Harmon, and up to 90 mph beyond the Hudson Highlands).

The Hudson Subdivision, a 38.6-mile line owned by CSX Transportation and leased by Amtrak, runs from Poughkeepsie to Albany-Rensselaer. The relatively straight section allows for speeds of up to 110 mph, the highest maximum speeds on the Empire Corridor South.
Route 2 would involve the use of CSX's Schodack Subdivision (Fig. 3), a line which branches off of the Hudson Division at Suyvesant. 3,000 feet of new connection track would join this with CSX's Berkshire Subdivision just south of Castleton-on-Hudson, where New York State's Route 9J and NY 912M (the New York State Thruway's Berkshire Connector) meet. As mentioned above, a total of 11 miles of track would be utilized for which there is currently no Amtrak-CSX agreement.
III. Market Research

Our class group (BFOR) solicited information from attractions and lodgings in Berkshire County, lists of which were provided by the BFWG. We obtained e-mail addresses and telephone numbers for these attractions and lodgings, and sent an e-mail to each requesting data on the proportion of their visitors/customers/guests who were from the New York City metropolitan area (see Appendices A-B).

We created a Google account, "MCLA Flyer," from which attractions/locations were e-mailed. A Google survey was developed that we hoped would be disseminated to any member lists that be might be kept by these attractions/lodgings, and/or shared on social media accounts. Each e-mail included a request for relevant information and a link to the survey (see Appendices B-D).

A total of 70 attractions, 6 chambers of commerce, and 173 lodgings were contacted. Of these, 20 attractions, 2 chambers of commerce, and 10 lodgings responded. 1 Berkshire, Berkshire Theatre Group, Mass MoCA, and the town of North Adams agreed to post a link to our survey on their respective social media accounts (e.g. Facebook), yielding approximately 450 responses.
A. Information from Attractions and Lodgings in Berkshire County

Data was obtained regarding seasonal attendance from five representative attractions/lodgings in Berkshire County. These businesses responded to our e-mail by providing numbers of guests/customers/visitors during the summer season, as well as the percentage of these visitors from the New York City metropolitan area (see Table I). E-mail correspondences with these businesses are available in Appendix C.

TABLE I
Seasonal attendance at representative sample of Berkshire county attractions/lodgings

<table>
<thead>
<tr>
<th>Attraction/Lodging</th>
<th>Seasonal attendance</th>
<th>Percentage of visitors from NYC Metro Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berkshire Scenic Railway Museum</td>
<td>10,121&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.7%</td>
</tr>
<tr>
<td>Gateways Inn &amp; Restaurant</td>
<td>1,500&lt;sup&gt;b,d&lt;/sup&gt;</td>
<td>40%</td>
</tr>
<tr>
<td>W.E.B. Du Bois National Historic Site</td>
<td>1,800&lt;sup&gt;b,d&lt;/sup&gt;</td>
<td>10%</td>
</tr>
<tr>
<td>Canterbury Farm B&amp;B</td>
<td>280</td>
<td>75%</td>
</tr>
<tr>
<td>Berkshire Theatre Group</td>
<td>7,500&lt;sup&gt;b,d&lt;/sup&gt;</td>
<td>16%</td>
</tr>
<tr>
<td>Frelinghuysen Morris House &amp; Studio</td>
<td>2,500&lt;sup&gt;b&lt;/sup&gt;</td>
<td>50%</td>
</tr>
</tbody>
</table>

<sup>a</sup>May 2016-December 2017  
<sup>b</sup>Approximate values.  
<sup>c</sup>June 15-September 15, 2017.  
<sup>d</sup>July-September 2017.  
<sup>e</sup>June-August 2017.

Berkshire Scenic Railway Museum is a non-profit organization with a mission “to preserve the history of railroading, particularly in the Berkshire Hills of Western Massachusetts.” [8] Featuring a number of vintae locomotives and passenger cars, BSRM offers educational exhibits, restorations, and service on traditional and historic train rides.

The Gateways Inn & Restaurant is a bed and breakfast located at the Procter mansion at 51 Walker Street in downtown Lenox. It has been featured in Gladys Magazine, called “the must-stay place” in Lenox by Luxury Report Magazine, named one of the “Best Places to Stay in Massachusetts” by The Hotel Guru, and is the winner of a 2014 “Best of New England - Editor’s Choice” award by Yankee Magazine [9]. From June 15th to September 15th, the Gateways Inn had approximately 1,500 guests, of which an estimated 40% (600) were from New York City; this becomes 75% (1,125) if New Jersey and Connecticut are included.
The W.E.B. Du Bois National Historic Site, at 612 South Egremont Road in Great Barrington, hosts the boyhood homesite of the African-American intellectual and civil-rights activist W.E.B. Du Bois. Listed on the National Register of Historic Places, it is currently operated an all-volunteer committee. The five-acre site includes guided tours along an interpretive trail [10]. During tour season, from July to September, the site receives approximately 60 visitors per month; 10% of visitors stated that they were from New York City.

Canterbury Farm is a nordic center and bed & breakfast located at 1986 Fred Snow Road in Becket. Open to the public throughout the year, Canterbury Farm offers seasonal outdoor activities (from skiing and snowshoeing to hiking, swimming, and kayaking) as well as lodging and musical events. The historic site, built in 1780 beside a 50-acre lake [11], hosted 280 guests during the summer of 2017; 75% (210) were from New York City. Guests stayed at the farm two days on average.

Berkshire Theatre Group is a non-profit organization that came about when Berkshire Theatre Festival merged with The Colonial Theatre, two of Berkshire County’s oldest performing arts venues. Both institutions have long and storied histories, each the site of hundreds of stage productions [12]. Berkshire Theatre Group now operates the Fitzpatrick Main Stage (83 East Main Street in Stockbridge), the Unicorn Theatre (6 East Street, Stockbridge) and The Colonial Theatre (111 South Street, Pittsfield). From June to August of 2017, the Berkshire Theatre Group saw approximately 7,500 ticket orders; of these, 1,200 (16%) were made by people from the New York City metro area.

Frelinghuysen Morris House & Studio is the home of American abstract artists George L.K. Morris and Suzy Frelinghuysen. The 46-acre estate at 92 Hawthorne Street in Lenox allows visitors to view the couple’s artwork and living quarters firsthand [13]. Frelinghuysen Morris House & Studio is open from late June to early October, and receives approximately 2,500 visitors every season; roughly 50% are from the New York metro area.

B. Berkshire Flyer Ridership Survey

The Berkshire Flyer Ridership Survey was created using Google forms (see Appendix D for the full survey). As mentioned in Section II, our class (BFOR) emailed the survey link (https://goo.gl/forms/isHQRkn3NMJorDL43) to 70 attractions, 6 chambers of commerce, and 173 lodgings (all but the chambers of commerce were obtained from a list provided by the working group; see Appendix A). We asked the establishments if they would be willing to share the survey with their customers/members/visitors via any existing mailing lists or social media accounts. Social media solicitation attracted the majority of the responses.

It’s important to acknowledge that our results do not represent a random sample of potential passengers; respondents were mostly those who follow Berkshire County-based businesses on social media (and therefore do not represent the target demographic, i.e. New Yorkers), and respondents were necessarily restricted to those inclined to participate in online surveys regarding Berkshire County rail travel. Nevertheless, as of December 17, 2017, there have been over 450 responses. Full response data was automatically compiled into a spreadsheet where it is ordered by submission date (see Appendix E).

The survey is composed of twelve questions divided into four sections; four demographic questions were optional. Section I asked respondents, “Are you in favor of expanding rail service between the Berkshires and NYC?” and “Would you use this service if it existed?” If respondents answered the latter by selecting either “I would not use this service but I know
people that would” or “I would not use this service and I do not know anyone that would,” the survey’s branching behavior brought them to the last section (section 4), which asks how much they currently pay for transportation to the Berkshires as well as (optionally) the respondent’s race and income (see Appendix D).

**Are you in favor of expanding rail service between the Berkshires and NYC?**

![Pie chart showing 99.1% favor and 0.9% against expanding rail service between the Berkshires and NYC.]

**Fig. 5** Berkshire Flyer Ridership Survey: Response to section 1 question 1 as of Dec. 17, 2017

Respondents were then asked if they would use the service or if they knew friends/family that would. The majority of respondents indicated that they would either personally use the service or knew someone who would.

**Would you use this service if it existed?**

![Pie chart showing 51.8% would use the service, 42.7% would not use it, and 5.5% would not know anyone that would.]

**Fig. 6** Berkshire Flyer Ridership Survey: Response to section 1 question 2 as of Dec. 17, 2017 (If respondents indicated that they would not use this service, sections 2 and 3 were skipped)

The survey asked participants about the frequency and duration of their visits in the Berkshires. The majority of respondents indicated that they would use the service on a monthly basis; however, another third of the respondents indicated that they would use the service yearly.
The typical time spent visiting the Berkshires ranged from a few days to more than one week. It is worth mentioning that a large group of respondents (approximately 40%) already lived in the Berkshires. The following were the three most popular responses:

- A few days (31.3%)
- More than a week (18.4%)
- A week (6.9%)

Participants were asked the reason they would be visiting the Berkshires, and provided some of the following responses:

- Cultural attractions (30.5%)
- Visiting friends and family (25.3%)
- Hiking/camping/fishing (3.3%)
- Skiing/snowboarding (1.2%)

Most other respondents indicated that they already lived in the Berkshires.

The participants were also asked what their final destination would be when coming to the Berkshires. While responses varied widely, the top destinations mentioned were the following cities/towns:

- Pittsfield (22.4%)
- North Adams (15.5%)
- Lenox (13.8%)
- Williamstown (9.5%)
- Great Barrington (9.1%)
- Lee (2.9%)
Our class (BFOR) was also interested in obtaining information on the maximum amount respondents would be willing to pay over current rates in order to bypass Albany-Rensselaer (Route 2). When asked how much more the respondent would be willing to pay to cut twenty minutes off the current travel time to NYC, responses ranged from $0-$200, with some respondents noting that they were unsure or gave answers such as “Whatever it took.” The upper range of responses were large enough to suggest that respondents may have been entering the total prices they were willing to spend; our group had intended the question to refer only to additional money spent in order to save twenty minutes of travel time. A lack of clarity in the phrasing of the question may have led to the responses.

In an effort to minimize inappropriate skewing of data, we decided that $60 would be the upper maximum for a reasonable response. Responses that did not fall between the range of $0-$60 were treated as if the response was left blank. With this in mind, the average amount of money a respondent would be willing to pay on top of the cost of travel in order to save twenty minutes per trip is $23.32 (see Appendix E).

What would be your seating preference aboard the train?

419 responses

Fig. 8 Berkshire Flyer Ridership Survey: Response to section 3 question 5 as of Dec. 17, 2017

Finally, BFOR asked respondents about their total household income. We obtained the following responses:
C. **Statistical Analysis of Survey Data**

By analyzing the data collected from survey, we identified unreliable responses by removing any that had the following: words where numerical values were needed, incomplete or only half-answered responses, and any duplicate responses. At the time of the statistical analysis, there were approximately 200 survey responses, of which only about 120 were useful.

Our analysis showed that only household total income has a statistically significant impact on whether a respondent would ride alone or with family (household income was found to account for more than 62.4% of original data).

As the total household income increases, fewer people would choose to travel by themselves when using the Berkshire Flyer service. For those whose household income is between $70,000 to $100,000, 54% would choose to go on their own while 48% among those who made $100,000 to $150,000 would do so, and 43% of those who made $150,000 to $200,000, and 38% of those made greater than $200,000. For more details of the statistical analysis, see Appendix F.

D. **Berkshire County homeowners who live in New York City**

In order to better gauge potential ridership for the Berkshire Flyer service, BFOR sought to determine the number of Berkshire County homeowners whose property tax bills were sent to addresses in the New York metropolitan area. This population consists of individuals who own properties in the Berkshires while living in New York City; this includes those who own second homes, seasonal residences, rental properties, etc. Those who own second homes in the Berkshires presumably maintain reliable patterns of travel from New York City, and may represent an untapped market for future rail service.

Information was obtained from the Massachusetts Bureau of Geographic Information (MassGIS) ArcGIS Online Web mapping platform [14]. Standardized parcels data were downloaded for every town in Berkshire County north of Great Barrington (see Appendix G). Owner addresses with zip codes between 10001 and 11980 were considered to be within the New York metropolitan area. Esri’s ArcGIS was used to plot addresses for nine Berkshire towns.
with the greatest numbers of tax bills mailed to New York addresses; Alford, Becket, Hancock, Lee, Lenox, Pittsfield, Stockbridge, Williamstown, and West Stockbridge (Fig. 10 and Table II).

In Figure 11, the broader Hudson Valley area is shown, and six stations along the proposed route have been used to generate a Voronoi diagram, which shows colored regions where each point is closest, geographically, to the station within that region. The six stations used to generate the Voronoi cells were New York Penn Station (NYP), Yonkers (YNY), Croton-on-Hudson (CRT), Poughkeepsie (POU), Rhinecliff (RCH), and Hudson (HUD). Dots are shown on the map for ZIP codes that are within 30 miles of each station. Geospatial coordinates of ZIP codes was done using the zipcodes package for the python programming language [15], and distance to each station was computed by the script in Appendix H.
Fig. 11 ZIP codes overlaid on Voronoi diagram of stations along proposed route.

TABLE II
Berkshire County cities/towns with highest number of property-owners in NYC

<table>
<thead>
<tr>
<th>City/Town</th>
<th>Tax bills</th>
<th>Tax bills mailed to NYC metro zip codesa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alford</td>
<td>523</td>
<td>92</td>
</tr>
<tr>
<td>Becket</td>
<td>4082</td>
<td>294</td>
</tr>
<tr>
<td>Hancock</td>
<td>960</td>
<td>186</td>
</tr>
<tr>
<td>Lee</td>
<td>3059</td>
<td>171</td>
</tr>
<tr>
<td>Lenox</td>
<td>2879</td>
<td>211</td>
</tr>
<tr>
<td>Pittsfield</td>
<td>18694</td>
<td>166</td>
</tr>
<tr>
<td>Stockbridge</td>
<td>1959</td>
<td>271</td>
</tr>
<tr>
<td>Williamstown</td>
<td>2761</td>
<td>73</td>
</tr>
<tr>
<td>West Stockbridge</td>
<td>1120</td>
<td>114</td>
</tr>
</tbody>
</table>

aZip codes between 10001 to 11980 were considered to be within the New York metropolitan area.
bNew York Penn Station
### TABLE III

Numbers of tax bills mailed within 30 and 50 mile radii of six stations along proposed route

Report automatically generated by Python on the basis of MassGIS data.

| City name       | Total tax bills | NY/NJ | 30 mile | 50 mile | NYP30 | YNPS0 | NY30 | YNYS0 | CRT30 | CRT50 | POU30 | POU50 | RH130 | RH150 | HUD30 | HUS |
|-----------------|-----------------|-------|---------|---------|-------|-------|------|-------|-------|-------|-------|-------|-------|-------|-----|
| Adams           | 5638            | 21    | 15      | 17      | 6     | 6     | 2    | 2     | 3     | 3     | 0     | 0     | 1     | 4    |     |
| Alford          | 523             | 124   | 112     | 121     | 77    | 83    | 15   | 15    | 12    | 15    | 1     | 1     | 0     | 7    |     |
| Becket          | 4082            | 377   | 317     | 345     | 145   | 154   | 88   | 88    | 64    | 82    | 2     | 2     | 2     | 2     | 16  |
| Cheshire        | 1733            | 15    | 16      | 21      | 10    | 10    | 2    | 2     | 2     | 2     | 5     | 0     | 0     | 0     | 2   |
| CLARKSBURG      | 845             | 11    | 6       | 10      | 2     | 2     | 3    | 3     | 1     | 1     | 0     | 0     | 0     | 1     | 0   |
| DALTON          | 2772            | 24    | 19      | 32      | 11    | 13    | 1    | 1     | 2     | 3     | 2     | 2     | 0     | 0     | 3   |
| Egremont        | 1252            | 259   | 241     | 254     | 169   | 171   | 36   | 36    | 27    | 38    | 0     | 0     | 0     | 3     | 6   |
| Florida         | 693             | 26    | 13      | 17      | 8     | 8     | 2    | 2     | 1     | 4     | 0     | 0     | 0     | 0     | 2   |
| Great Barrington| 4136            | 329   | 301     | 314     | 197   | 205   | 40   | 40    | 39    | 44    | 3     | 3     | 3     | 3     | 19  |
| HANCOCK         | 960             | 280   | 224     | 248     | 77    | 81    | 45   | 45    | 59    | 79    | 2     | 2     | 1     | 1     | 40  |
| Hinsdale        | 1528            | 88    | 81      | 84      | 17    | 17    | 20   | 20    | 15    | 18    | 2     | 2     | 2     | 2     | 12  |
| LANCESBOUR      | 2054            | 81    | 71      | 74      | 16    | 28    | 23   | 23    | 17    | 18    | 1     | 1     | 1     | 1     | 13  |
| Lee             | 3059            | 246   | 219     | 236     | 124   | 134   | 45   | 46    | 32    | 39    | 1     | 1     | 1     | 1     | 15  |
| LENOX           | 2879            | 280   | 255     | 266     | 135   | 143   | 57   | 57    | 51    | 53    | 0     | 0     | 2     | 2     | 10  |
| New Ashford     | 208             | 10    | 6       | 9       | 2     | 3     | 3    | 1     | 2     | 1     | 0     | 0     | 0     | 0     |     |
| NORTH ADAMS     | 5933            | 72    | 51      | 62      | 30    | 35    | 5    | 5     | 3     | 3     | 1     | 1     | 1     | 1     | 10  |
| Peru            | 792             | 33    | 28      | 32      | 10    | 11    | 4    | 4     | 3     | 4     | 7     | 0     | 0     | 2     | 8   |
| PITTSFIELD      | 18694           | 292   | 252     | 268     | 111   | 117   | 43   | 43    | 45    | 51    | 1     | 1     | 2     | 3     | 50  |
| Richmond        | 1260            | 109   | 100     | 103     | 54    | 57    | 9    | 9     | 19    | 19    | 0     | 0     | 0     | 0     | 18  |
| SAVOY           | 572             | 20    | 17      | 18      | 7     | 7     | 2    | 2     | 2     | 4     | 5     | 0     | 0     | 0     | 4   |
| Sheffield       | 2804            | 221   | 208     | 215     | 139   | 143   | 20   | 20    | 32    | 35    | 0     | 0     | 1     | 1     | 16  |
| STOCKBRIDGE     | 1959            | 365   | 342     | 357     | 222   | 233   | 50   | 50    | 58    | 62    | 0     | 0     | 2     | 2     | 10  |
| Washington      | 603             | 35    | 29      | 31      | 12    | 13    | 4    | 4     | 12    | 13    | 0     | 0     | 0     | 0     | 1   |
| West Stockbridge| 1120            | 143   | 132     | 139     | 86    | 90    | 24   | 24    | 13    | 16    | 0     | 0     | 0     | 0     | 9   |
| WILLIAMSTOWN    | 2761            | 101   | 94      | 96      | 57    | 58    | 9    | 9     | 19    | 19    | 1     | 1     | 0     | 0     | 8   |
| WINDSOR         | 901             | 26    | 22      | 23      | 14    | 14    | 3    | 3     | 3     | 3     | 4     | 0     | 0     | 0     | 2   |
| **Totals**      | **67221**       | **3598** | **3271** | **3582** | **1738** | **1826** | **556** | **556** | **538** | **638** | **17** | **17** | **24** | **27** | **298** | **51** |

### E. Service Economy

Once New Yorkers reach the Pittsfield Intermodal Station, there will be a demand for transportation services to get them to their final destination. These include: public bus service provided by the Berkshire Regional Transit Authority (BRTA), taxi service (e.g. Rainbow Taxi), as well as Uber, Lyft, Zipcar and Turo. Use of these services represents another economic benefit of bringing New Yorkers to Berkshire County.

BRTA provides fixed route bus service across Berkshire County, from Williamstown to Great Barrington, Monday through Saturday. A map of all BRTA bus routes (as of July 2017) is provided in Fig. 11: The lack of Sunday bus service as well route limitations may need to be addressed in order to better accommodate passengers disembarking from a potential Berkshire Flyer service in the near future.
IV. Future Research

Our group (BFOR) realized that businesses would be more willing to share the survey on social media only after it became clear that no business was willing to share our survey via direct, mass e-mail to their customers/members. It's also worth considering that relatively few businesses responded to our e-mails, despite our attempts to follow up with all attractions and lodgings. This may be due in part to the timing of the project (mostly undertaken during the Thanksgiving and winter holiday season).

Although several organizations based in Berkshire County shared our survey on social media, responses were mostly restricted to Berkshire residents. In order to disseminate our survey to potential ridership in the New York metropolitan area, we explored the option of
targeted advertising on Facebook. To this end, we created a Facebook account, “MCLA Flyer.” We determined that advertisements on Facebook can be targeted to users based on their interests (e.g., “Berkshires,” “Tanglewood,” etc). Our preliminary research revealed relevant numbers of users and their respective interests (see Table III).

It’s likely that many New Yorkers who already travel to locations such as upstate New York for recreation would also visit the Berkshires if a convenient public transit option were available. Thus, it’s important to identify individuals in this untapped market. Using Facebook’s targeted advertising to reach New York City users who have expressed interests in, e.g., “camping,” “train travel,” “Amtrak vacations,” etc., remains an unexplored opportunity.

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<tr>
<th>Interest</th>
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<td>“Lenox, Massachusetts”</td>
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<td>“Tanglewood Music Festival”</td>
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Alternative social media platforms on which targeted survey advertising could take place include Twitter, Instagram, Pinterest, Tumblr, Google+, and LinkedIn. These options have yet to be explored. Nevertheless, while Facebook tailors the reach of an advertising campaign to the given budget size, it’s clear that such advertising will require at least some financial investment in order to reach potential ridership in New York City.
REFERENCES


Appendix A: Attractions and Lodgings in Berkshire County

Attractions:

[link to the attractions list]

Lodgings:

[link to the lodgings list]
Lodgings:  
https://docs.google.com/spreadsheets/d/1xh0-mogmgAZ960Evz0tCZpBaSp1BZls1C0-Nhws/edit?usp=sharing
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<td><a href="mailto:innkeeper@countryinn.com">innkeeper@countryinn.com</a></td>
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<td>Country's Bed &amp; Breakfast - Now Airborne</td>
<td>1 East Street</td>
<td>Stockbridge, MA</td>
<td>01263</td>
<td><a href="mailto:countryinn@gmail.com">countryinn@gmail.com</a></td>
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<td>(413) 243-1215</td>
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<td><a href="mailto:helio82@hotmail.com">helio82@hotmail.com</a></td>
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<td><a href="mailto:info@hotelonboston.com">info@hotelonboston.com</a></td>
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<td>1120</td>
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<td>MA 01267</td>
<td><a href="mailto:rein@newenmainstreet.com">rein@newenmainstreet.com</a></td>
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<td>906</td>
<td>Will Rise G. De New Marlboro</td>
<td>MA 01244</td>
<td><a href="mailto:freemancollins@gmail.com">freemancollins@gmail.com</a></td>
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<td>Inn at Richmond &amp; Berkshires Express</td>
<td>802</td>
<td>State Rd</td>
<td>Richmond</td>
<td>MA 01264</td>
<td><a href="mailto:marceledoct@gmail.com">marceledoct@gmail.com</a></td>
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<td>301</td>
<td>East St</td>
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<td>Pinecrest Lake</td>
<td>Great Barrington</td>
<td>MA 01230</td>
<td><a href="mailto:stay@skunkcreek.com">stay@skunkcreek.com</a></td>
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<td>abel@桕nessinn.com</td>
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<td><a href="mailto:mkgib@tsnn.com">mkgib@tsnn.com</a></td>
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<td>Maple Terrace Motel</td>
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<td><a href="mailto:mkgibott@gmail.com">mkgibott@gmail.com</a></td>
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<td><a href="mailto:mkgibott6@gmail.com">mkgibott6@gmail.com</a></td>
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<td><a href="mailto:info@raveblodge.com">info@raveblodge.com</a></td>
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<td><a href="mailto:info@rockwoodinn.com">info@rockwoodinn.com</a></td>
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<td><a href="mailto:info@berkshireridgeinn.com">info@berkshireridgeinn.com</a></td>
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<td><a href="mailto:stonewaterfarm@comcast.com">stonewaterfarm@comcast.com</a></td>
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<td><a href="mailto:stay@tolphill.com">stay@tolphill.com</a></td>
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<td>Waugh Wheel Inn</td>
<td>893</td>
<td>Pittsfield Road Lenox MA</td>
<td>01240</td>
<td><a href="mailto:info@waughwheelinn.com">info@waughwheelinn.com</a></td>
<td>(413)445-1632</td>
<td></td>
</tr>
<tr>
<td>146</td>
<td>Windward Inn</td>
<td>510</td>
<td>S Main St Great Barrington MA</td>
<td>01230</td>
<td><a href="mailto:innkeeper@windwardinn.com">innkeeper@windwardinn.com</a></td>
<td>(413)237-7062</td>
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<tr>
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<td>675</td>
<td>S Main St Lanesborough MA</td>
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<td>None</td>
<td>(413)343-3230</td>
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<tr>
<td>148</td>
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<td>11</td>
<td>Hawtreeve St Lanesborough MA</td>
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<td><a href="mailto:info@wheelwrightinn.com">info@wheelwrightinn.com</a></td>
<td>(413)343-3230</td>
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<tr>
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<td><a href="mailto:info@wheatsheaffinn.com">info@wheatsheaffinn.com</a></td>
<td>(413)347-2078</td>
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Appendix B: MCLA Flyer E-mail Sent to Attractions & Locations

Greetings from the students of MATH-444 Operations Research at the Massachusetts College of Liberal Arts!

Our class has teamed up with the Berkshire Flyer working group (which includes members of the Massachusetts state government and MassDOT) to analyze a possible passenger train service from New York City to Berkshire County. The Berkshire Flyer would provide seasonal, weekend service from NYC's Penn Station to Pittsfield. Our class project involves gathering data on potential ridership, and you may be able to help!

[Attraction name] has been identified as a potential destination for travelers from New York City who might use the Berkshire Flyer service. We'd definitely be interested in any data on your [members/visitors/guests], including:

- The proportion of your members coming from the New York City metropolitan area--ZIP codes or area codes would be helpful
- The number of [visitors/guests] coming from the New York City metropolitan area--ZIP codes or area codes are helpful
- The number of [visitors/guests] per day/week/month, over the past few summers
- [The numbers of visits by members per day/week/month, over the past few summers]
- Durations of visits [if applicable---e.g., would ask a resort, but not a museum]

To further help with our research on future Berkshire Flyer service, our class has also developed a survey, linked here: https://goo.gl/forms/mTb3LbMg5eAebili2.

We are hoping that this survey will reach people who might regularly travel from New York City to the Berkshires, and therefore wonder whether it would be possible for you to e-mail this survey to your members? If needed, we can edit the survey to create a version specific for [attraction name] Please let us know!

We look forward to hearing from you at your earliest convenience.

Thank you, in advance, for your help!

The students of MATH-444 Operations Research

Massachusetts College of Liberal Arts
375 Church Street
North Adams, MA 01247

on behalf of

The Berkshire Flyer Working Group
http://www.massdot.state.ma.us/planning/Main/CurrentStudies/BerkshireFlyerStudy.aspx
Appendix C: E-mail correspondence with Attractions & Locations

On Sun, Nov 26, 2017 at 12:14 PM Kevin M. Chittenden <kchittenden@berkshirescenicrailroad.org> wrote:

Hello Math-444. ORI!

BSRM has been a member of the working group so we are familiar with it.

Let me take this to our board to discuss the best approach. We do have a mailing list of visitors can certainly get an idea of how many come from the NYC area - however, it maybe more difficult to get exact numbers as the tickets purchased per contact are not readily accessible in that manner but I’ll give it a look.

We may too be able to send out a targeted email to NYC attendees - also something I’ll have to research a little

Give me a bit and I’ll get back with you.
Thanks for reaching out to us,
Kevin

Kerla M Chittenden
Superintendent, Train Operations
Berkshire Scenic Railway Museum, Inc.
(413) 537-6766 (cell)

http://www.berkshirescenicrailroad.org
Rebecca Brightent

to me, Bax, Madelyn -

Hi there,

The basic data we pulled based on your request is this:
For the summer of 2017 (June, July and August)
We had approximately 7500 ticket orders, of which approximately 1200 were from the greater NYC metro area.
We hope this helps and whole heartedly support train service to the Berkshires!

Best,
Becky

On Thu, Dec 14, 2017 at 3:30 PM, MCLA Berkshire Flyer <mclaflyer@gmail.com> wrote:
Hi Rebecca,

Most helpful would be the number of visitors to events held during the summer season (June, July, and August) in the most recent year for which data is available, and the percentage of those visitors who were from the New York City metropolitan area (if this is known).

Thanks again!

On Thu, Dec 14, 2017 at 3:13 PM, Rebecca Brightent <becky@berkshiretheatre.org> wrote:
Since that deadline is quickly approaching, what data would be most helpful at this time?

On Thu, Dec 14, 2017 at 3:09 PM, MCLA Berkshire Flyer <mclaflyer@gmail.com> wrote:
Hi Rebecca,

Thank you so much for sharing our survey on social media.
Our deadline for any additional data would be this Friday the 15th.

Thanks again for your help.
We look forward to receiving your response!

The students of MATH-441 Operations Research
Massachusetts College of Liberal Arts
23 Church Street
North Adams, MA 01247

on behalf of
The Berkshire Flyer Working Group http://www.massdot.state.ma.us/planning/Main/CurrentStudies/BerkshireFlyerSurvey.aspx

On Thu, Dec 14, 2017 at 12:51 PM, Rebecca Brightent <becky@berkshiretheatre.org> wrote:
Dear MCLA Students,
Thank you for reaching out regarding this very important topic. When is your deadline for receiving this data?
In the meantime, we are happy to post your market survey on social media.

Best,
Becky Brightent
Hello Students,
Here is an excerpt from our mailing list showing the NYC team and zip codes, you will find the attachment above.
These people have either visited or are members.
Also, I have just sent out the survey to our email list.
We have approximately 2500 visitors per season. The percentage of NYC area residents is about 50%, however that is not just NYC.
We are open 4 days a week from late June to Early October.
Good luck with the project.
I suggest you find the facebook page which is set up for people seeking rides from the Metro-North RR station at Vanasnic to GB or Lenox. You may get a lot of info there or post something.
Sincerely,
Linda Frelinghuyzen

Linda Bacon <canterburybacon@gmail.com>

Canterbury Farm B&B has been identified as a potential destination for travelers from New York City who might use the Berkshire Flyer service. We'd definitely be interested in any data on your guests, including:

- The proportion of your guests coming from the New York City metropolitan area--ZIP codes or area codes are helpful. During the summer 75% come from New York. During the winter most come from CT and MA.
- The number of guests per day/week/month, over the past few summers. Summer 200 lodging user days (may include two persons). Winter: 80 lodging user days (may include two persons). Skiing day ticket holders varies between 60-200 persons per day.
- Durations of the average visit, two days average visit

Hope this information helps.

Linda Bacon
Carrieha Scruggs <cscruggs@umass.edu>  Nov 27, 2017

To Whom It May Concern:

To answer your inquiry, this data is based on the 2016 and 2017 tour seasons. Tour season is July - September.

The average number of visitors per month is 60. This does not include visitors to the site before or after operating hours.

I hope this helps with your inquiry.

Best,

Carrieha Scruggs
Summer 2016 and 2017 Tour guide

On 2017-11-24 08:23 PM, MCLA Berkshire Flyer wrote:

Greetings from the students of MATH 444: Operations Research at the Massachusetts College of Liberal Arts!

Our class has teamed up with the Berkshire Flyer working group (which includes members of the Massachusetts state government and MassDOT) to analyze a possible passenger train service from New York City to Berkshire County. The Berkshire Flyer would provide seasonal weekend service from NYC’s Penn Station to Pittsfield. Our class project involves gathering data on potential ridership, and you may be able to help!

W.E.B. Du Bois National Historic Site has been identified as a potential destination for travelers from New York City who might use the Berkshire Flyer service. We’d definitely be interested in any data on your visitors/guests, including:

- The percentage of your visitors and/or members coming from the New York City metropolitan area—ZIP codes or area names would be helpful.
- The number of visitors per day/week/month over the past few summers

To further help us with our research on future Berkshire Flyer service, our class has also developed a survey, linked here:
https://goo.gl/forms/mTbh3LbMg6eA6uiz2 [1]

We are hoping that this survey will reach people who might regularly travel from New York City to the Berkshires, and therefore wonder whether it would be possible for you to e-mail this survey to any member list you might have? If needed, we can edit the survey to create a version specific for W.E.B. Du Bois National Historic Site. Please let us know!

We look forward to hearing from you at your earliest convenience.

Thank you, in advance, for your help!

The students of MATH 444: Operations Research

on behalf of

The Berkshire Flyer Working Group
Appendix D: Berkshire Flyer Ridership Survey

Section 1 of 4

Berkshire Flyer Ridership Survey

The Berkshire Flyer Group is examining the possibility of establishing a seasonal weekend passenger service between Pittsfield and New York City by expanding Amtrak’s existing options. Market research is needed to determine the feasibility of this proposal. So, we want to ask you the following questions in the hope of being able to evaluate the demand for this type of service.

Thank you for taking the time to fill out the survey and sharing your thoughts on this study.

Are you in favor of expanding rail service between the Berkshires and NYC?

- Yes
- No

Would you use this service if it existed?

- I would personally use this service.
- My friends/family and I would use this service.
- I would not use this service but I know people that would
- I would not use this service and I do not know anyone that would
Section title (optional)

What is your age?

- 17 and under
- 18-20
- 21-42
- 43-55
- 56-64
- 65+

Section title (optional)

How often would you use this service?

- Yearly
- Monthly
- Weekly
How long do you typically spend visiting the Berkshires? *

- A single day
- A few days
- A week
- More than a week
- Other

For what reasons would you be visiting the Berkshires? *

- Hiking/camping/fishing
- Skiing/snowboarding
- Cultural attractions
- Visiting friends and family
- Other

What is your final destination when coming to the Berkshires? *

- Lee
- Lenox
- Great Barrington
- Pittsfield
- North Adams
- Williamstown
- Other
What would be your seating preference aboard the train?

- Coach class
- Business class
- First class

Service on currently existing lines changes trains at Albany-Rensselaer station, and takes around 5 hours; if the Berkshire Flyer were to run a dedicated train on this same line, it would take around 4 hours. If the new service were to bypass Albany-Rensselaer, the travel time could be further reduced by around 20 minutes. What is the maximum amount you would pay in order to bypass Albany-Rensselaer on the new service?

Short answer text:

Section 4 of 4

Section title (optional)

How much do you currently pay for transportation to the Berkshires?

Short answer text:

(OPTIONAL) Are you of Hispanic, Latino, or Spanish origin?

- Yes
- No
(OPTIONAL) What is your household's total income?

- Less than $30,000
- $30,000 to $70,000
- $70,000 to $100,000
- $100,000 to $150,000
- $150,000 to $200,000
- More than $200,000

(OPTIONAL) Check any that apply.

- White
- Black or African American
- Asian
- Native Hawaiian or Pacific Islander
- Native American or Alaskan Native
- Other
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<th>Address</th>
<th>Phone</th>
<th>Email</th>
<th>Web</th>
<th>Notes</th>
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<tbody>
<tr>
<td>123 Main St, Anytown, USA</td>
<td>(123) 456-7890</td>
<td><a href="mailto:anytown@gmail.com">anytown@gmail.com</a></td>
<td><a href="http://www.anytown.com">www.anytown.com</a></td>
<td>Notes about the client's address are here.</td>
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<tr>
<td>456 Oak Ave, Cityville, USA</td>
<td>(234) 567-8901</td>
<td><a href="mailto:cityville@any.com">cityville@any.com</a></td>
<td><a href="http://www.cityville.com">www.cityville.com</a></td>
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<tr>
<td>789 Pine Rd, Townsville, USA</td>
<td>(345) 678-9012</td>
<td><a href="mailto:townsville@xyz.com">townsville@xyz.com</a></td>
<td><a href="http://www.townsville.com">www.townsville.com</a></td>
<td>Notes about the client's address are here.</td>
</tr>
<tr>
<td>Date</td>
<td>Action</td>
<td>Description</td>
<td>Contact</td>
<td>Fee</td>
</tr>
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<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------</td>
<td>--------------</td>
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</tr>
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<td>My friends/family and 19-30</td>
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<tr>
<td>12/24/2017</td>
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<td>$40</td>
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For more details, please contact the relevant party as provided.
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<tr>
<th>Date</th>
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<tr>
<td>1/22/2017</td>
<td>Monthly Family gathering</td>
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<td>1/31/2017</td>
<td>Monthly Family gathering</td>
<td>Walk in the Berkshires, Performing Arts Cruise, Coach 90, 100, 150</td>
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</table>

**Note:** The events listed above are monthly family gatherings and include various activities such as walking, cruising, and performing arts. The details provided are specific to the dates listed, indicating the type of event and the associated coach numbers. The costs mentioned are specific to the events, with some costs ranging from $50.00 to $500.00.
<table>
<thead>
<tr>
<th>Date</th>
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<th>Visitor Name</th>
<th>Frequency</th>
<th>Accommodation Type</th>
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<td>My ex-spouse and ex-4, 31-42</td>
<td>Yearly</td>
<td>A week at in-laws</td>
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<td></td>
<td>$100,000 to $150,000</td>
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<td>Monthly</td>
<td>More than a week</td>
<td>Laguna</td>
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<td>Monthly</td>
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<td>My friends personally use 128-30</td>
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<td>Occonal To say</td>
<td>C: No</td>
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<td>$100,000 to $150,000</td>
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Appendix F: Statistical Analysis of Data

Results showed that only household total income has a statistically significant impact on whether a respondent would ride alone or with family (household income was found to account for more than 62.4% of original data).

### Omnibus Tests of Model Coefficients

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<th>Sig.</th>
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<td>.045</td>
</tr>
<tr>
<td>Block</td>
<td>4.002</td>
<td>1</td>
<td>.045</td>
</tr>
<tr>
<td>Model</td>
<td>4.002</td>
<td>1</td>
<td>.045</td>
</tr>
</tbody>
</table>

Chi-square test with a significance level of 0.05 for household total income is 4.002 and exceeds critical value 3.84. The p-value in this test is 0.045 which is below 0.05, indicating that our findings were statistically significant.

### Variables in the Equation

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<tr>
<th>Step 1</th>
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<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
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<td>.801</td>
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<td>.401</td>
<td>4.307</td>
<td>1</td>
<td>.038</td>
<td>2.296</td>
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</tbody>
</table>

From the result we get, we assume X as household total income and derive the prediction equation 1:

\[
p = 1 - \frac{1}{1 + e^{0.831 - 0.222 X}}
\]

Where: X is categorized into six groups, 1 for below 30,000; 2 for 30,000 to 70,000; 3 for 70,000 to 100,000; 4 for 100,000 to 150,000; 5 for 150,000 to 200,000; 6 for above 200,000.
Appendix G: Maps of Tax Bill Addresses

Tax Bills Mailed from Adams

Tax Bills Mailed from Alford
Tax Bills Mailed from Egremont

Tax Bills Mailed from Florida
Tax Bills Mailed from Great Barrington

Tax Bills Mailed from Hancock
Tax Bills Mailed from New Ashford

Tax Bills Mailed from NORTH ADAMS
Tax Bills Mailed from Sheffield

Tax Bills Mailed from STOCKBRIDGE
Tax Bills Mailed from Washington

Tax Bills Mailed from West Stockbridge
Appendix H: Python Script for Generating City Maps Using MassGIS Data

#!/usr/bin/python
# Written by Erin Kiley <emkiley@mcla.edu>, latest revision Dec 18, 2017

from mpl_toolkits.basemap import Basemap # for drawing map
import matplotlib.pyplot as plt
import numpy as np
import re
import zipcodes
import geopy.distance # for computing distance between coordinates
from scipy.spatial import Voronoi
import glob # for listing .xlsx files
import openpyxl # for reading Excel files
from openpyxl.utils import get_column_letter, column_index_from_string

def is_number(s):
    try:
        float(s)
        return True
    except ValueError:
        pass

    try:
        import unicodedata
        unicodedata.numeric(s)
        return True
    except (TypeError, ValueError):
        pass

    return False

def check_dist_to_stations(lat,long,sta_lat,sta_long): # using Vicinity distance formula
    dists=[]
    coords_to_check = (long,lat)
    for i in range(0,len(sta_lat)):
        station_coords = (sta_long[i],sta_lat[i])
        dists.append(geopy.distance.vincenty(station_coords,coords_to_check).miles)
    #print dists
    return (min(dists),dists.index(min(dists)))

def get_zips(wbname): # gets addresses from specified Excel file, saves as array of strings
    wb = openpyxl.load_workbook(wbname)
    sheet = wb.active
    zips=[]
    unique_addrs = []
    for i in range(2,sheet.max_row):
        addr = sheet.cell(row=i,column=column_index_from_string("R")).value
        if addr and addr not in unique_addrs:
            unique_addrs.append(str(addr))
            state = sheet.cell(row=i,column=column_index_from_string("U")).value
            if state:
                state = str(state)
                if state=="NY" or state=="NJ": # pick just the NY or NJ state addresses
                    ZIP = sheet.cell(row=i,column=column_index_from_string("V")).value
                    if ZIP:
                        ZIP = str(ZIP)

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ZIP = re.findall('[\d\d+]', ZIP)[0]  # gets the first number in the string
(avoiding any ZIP+4 issues, and gets a too-short number from non-US codes with alphabetic characters)

if zipcodes.is_valid(ZIP):
    ziptdata = zipcodes.matching(ZIP)[0]
    zips.append(zipdata.get('zip_code'))
return (zips, sheet.max_row)

def get_unique_zips(zips):
    skinny_zips = list(set(zips))  # gets unique values
    counts = [zips.count(zip) for zip in skinny_zips]  # counts occurrences
    return (skinny_zips, counts)

def get_coords(zips):
    lats = []
    longs = []
    for zip in zips:
        ziptdata = zipcodes.matching(str(zip))[0]
        lats.append(zipdata.get('lat'))
        longs.append(zipdata.get('long'))
    return (lats, longs)

def get_cityname(wbname):
    wb = openpyxl.load_workbook(wbname)
    sheet = wb.active
    cityname = sheet.cell(row=2, column=index_from_string('P')).value
    return cityname

def get_data(lats, longs, fcity, fcityy30, fcityy50, fny30, fny50, station_latitudes, station_longitudes):
    # gets coordinates from addresses, saves as coordinates
    lat30 = []
    long30 = []
    lat50 = []
    long50 = []
    station50 = [0] * len(station_latitudes)
    station30 = [0] * len(station_latitudes)
    for lat, long in zip(lats, longs):
        fcity.write(str(lat) + ', ' + str(long) + '
')
        [dist_to_stations, which_sta] = check_dist_to_stations(lat, long, station_latitudes, station_longitudes)
        if dist_to_stations <= 30.0:
            lat30.append(lat)
            long30.append(long)
            fcityy30.write(str(lat) + ', ' + str(long) + '
')
            fny30.write(str(lat) + ', ' + str(long) + '
')
            lat50.append(lat)
            long50.append(long)
            fcityy50.write(str(lat) + ', ' + str(long) + '
')
            fny50.write(str(lat) + ', ' + str(long) + '
')
            station30[which_sta] = station30[which_sta] + 1
            station50[which_sta] = station50[which_sta] + 1
        elif dist_to_stations <= 50.0:
            fcityy50.write(str(lat) + ', ' + str(long) + '
')
            fny50.write(str(lat) + ', ' + str(long) + '
')
            lat50.append(lat)
            long50.append(long)
            station50[which_sta] = station50[which_sta] + 1
            station50[which_sta] = station50[which_sta] + 1
    return (lat30, long30, lat50, long50, station30, station50)

def voronoi_finite_polygons_2d(vor, radius=None):
    Reconstruct infinite voronoi regions in a 2D diagram to finite regions.
Parameters

```
vor : Voronoi
    Input diagram
radius : float, optional
    Distance to 'points at infinity'.

Returns

regions : list of tuples
    Indices of vertices in each revised Voronoi regions.
vertices : list of tuples
    Coordinates for revised Voronoi vertices. Same as coordinates
    of input vertices, with 'points at infinity' appended to the end.
```

```
if vor.points.shape[1] != 2:
    raise ValueError("Requires 2D input")

new_regions = []
new_vertices = vor.vertices.tolist()

center = vor.points.mean(axis=0)
if radius is None:
    radius = vor.points.ptp().max()

# Construct a map containing all ridges for a given point
all_ridges = {}
for (p1, p2), (v1, v2) in zip(vor.ridge_points, vor.ridge_vertices):
    all_ridges.setdefault(p1, []).append((p2, v1, v2))
    all_ridges.setdefault(p2, []).append((p1, v1, v2))

# Reconstruct infinite regions
for p1, region in enumerate(vor.point_region):
    vertices = vor.regions[region]
    if all(v >= 0 for v in vertices):
        # finite region
        new_regions.append(vertices)
        continue

# Reconstruct a non-finite region
ridges = all_ridges[p1]
new_region = [v for v in vertices if v >= 0]

for p2, v1, v2 in ridges:
    if v2 < 0:
        v1, v2 = v2, v1
    if v1 >= 0:
        # finite ridge: already in the region
        continue

    # Compute the missing endpoint of an infinite ridge
    t = vor.points[p2] - vor.points[p1]  # tangent
    t /= np.linalg.norm(t)
    n = np.array([-t[1], t[0]])  # normal

    midpoint = vor.points[[p1, p2]].mean(axis=0)
    direction = np.sign(np.dot(midpoint - center, n)) * n
    far_point = vor.vertices[v2] + direction * radius
```
new_region.append(len(new_vertices))
new_vertices.append(far_point.tolist())

if s or t region counterclockwise
vs = np.array([new_vertices[v] for v in new_region])
c = vs.mean(axis=0)
angles = np.arctan2(vs[:, 1] - c[1], vs[:, 0] - c[0])
new_region = np.array(new_region)[np.argsort(angles)]

new_regions.append(new_region.tolist())
return new_regions, np.asarray(new_vertices)

# Define marker colors

# Define city landmarks
landmark_names = ['Paterson', 'Edison', 'Elizabeth', 'Newark', 'Yonkers', 'White Plains', 'Hempstead', 'West Point']
landmark_longitudes = [-74.173, -74.407, -74.21, -74.171, -73.9034, -73.762, -73.6216, -73.957449]
landmark_latitudes = [40.923, 40.511, 40.66, 40.73, 40.926, 41.0326, 40.7027, 41.38992]

# Define stations for Voronoi diagram
station_names = ['NYP', 'YNY', 'HUD', 'CRT', 'POU', 'RHI']
station_longitudes = [-73.993292, -73.902465, -73.798168, -73.882433, -73.937663, -73.951372]
station_latitudes = [40.750322, 40.935544, 42.253805, 41.189614, 41.707077, 41.921154]

# Draw base maps
plt.figure(1)
bigmap = Basemap(projection='merc', lat_0 = 41, lon_0 = -74,
resolution = 'f', area_thresh = 0.1,
llcrnrlon= -74.5789, llcrnrlat=40.557,
urcrnrlon= -72.36, urcrnrlat=42.43)

x,y = bigmap(station_longitudes, station_latitudes)
x_offsets = [-22500, -21000, 0, 0, 0, 0]
y_offsets = [0, 0, 0, 0, 0, 0]
for label, xpt, ypt, x_offset, y_offset in zip(station_names, x, y, x_offsets, y_offsets):
    plt.text(xpt+x_offset, ypt+y_offset, label)
points; np.column_stack((x,y))
vor = Voronoi(points)
regions,vertices = voronoi_finite_polygons_2d(vor)
#print regions
#椎 print vertices
for region in regions:
    polygon = vertices[region]
    print(*zip(*polygon), alpha=0.4)
plt.plot(points[:,0], points[:,1], 'ko', markersize=4)
plt.xlim(vor.min_bound[0] - 0.1, vor.max_bound[0] + 0.1)
plt.ylim(vor.min_bound[1] - 0.1, vor.max_bound[1] + 0.1)
bigmap.drawcoastlines()
bigmap.drawcountries()
# bigmap.fillcontinents(color = 'coral')
bigmap.drawmapboundary(fill_color='aqua')
bigmap.drawstates()
bigmap.drawrivers()

filenames = glob.glob('*.xlsx') # List all .xlsx files in an array
color_index = 0 # Starting index for cycling through marker colors

allny30 = open('All_30mi_Coords.txt', 'a')
allny50 = open('All_50mi_Coords.txt', 'a')
allreport = open('Report.txt', 'w')

allreport.write('Report automatically generated by Python on the basis of MassGIS data. 
NY/NJ refers to the number of tax bills mailed to New York or New Jersey addresses; '30 mile' and '50 mile' headings refer to the number of tax bills mailed to addresses within 30 or 50 miles (respectively) of one of the following stations: NYP, YNY, CRT, POU, RHI, HUD. Headings 'NYP30' and 'NY50' refer to the number of tax bills mailed to addresses within 30 or 50 miles (respectively) of NYP station; similarly for other stations. 

<table>
<thead>
<tr>
<th>City Name</th>
<th>Total Tax Bills</th>
<th>NY/NJ</th>
<th>30 Mile</th>
<th>50 Mile</th>
<th>NYP30</th>
<th>NYP50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

for file in filenames:
    cityname = get_cityname(file) # get the city's name
    print('Generating data and map for ' + cityname + '...')
    cityny30 = open(cityname + '_30mi_Coords.txt', 'w')
    cityny50 = open(cityname + '_50mi_Coords.txt', 'w')
    citycoords = open(cityname + '_NYNJ_Coords.txt', 'w')
    (zips, num_addrs) = get_zips(file) # get the ZIP codes for city tax bills
    (lats, longs) = get_coords(zips) # get latitudes and longitudes for ZIP codes
    (lat30, long30, lat50, long50, latstation30, latstation50) =
        get_data(lats, longs, citycoords, cityny30, allny30, cityny50, allny50, station_latitudes, station_longitudes) # get all the latitudes and longitudes for the city tax bills
    allreport.write(cityname + ' City ' + str(num_addrs) + ' Tax Bills

    dot_color = colors[color_index] # get the color for the dots
    if long30:
        counts = [long30.count(long) for long in long30] # counts the number of occurrences of each ZIP code
        maxct = max(counts)
        minct = min(counts)
        for i in range(1, len(long30)):
            x, y = bigmap(long30[i-1], lat30[i-1]) # get lat/long attributes for overall bigmap
            if maxct == minct:
                themarksize = 1
            else:
                themarksize = 3.0*(counts[i]-minct)/(maxct-minct) + 1.0
            bigmap.plot(x, y, color=dot_color, marker='o', markersize=themarksize) # add marker to overall bigmap, scaled by number of plots
```python
plt.figure(3)
plt.clf()
city_bigmap = Basemap(projection='merc', lat_0=41, lon_0=-74,
                       resolution='f', area_thresh=0.1,
                       llcrnrlon=-74.5789, llcrnrlat=40.557,
                       urcrnrlon=-72.36, urcrnrlat=42.43)

x, y = city_bigmap(station_longitudes, station_latitudes)
x_offsets = [-22500, -21000, 0, 0, 0, 0]
y_offsets = [0, 0, 0, 0, 0, 0]
for label, xpt, ypt, x_offset, y_offset in zip(station_names, x, y, x_offsets, y_offsets):
    plt.text(xpt + x_offset, ypt + y_offset, label)
points = np.column_stack((x, y))
vor = Voronoi(points)
regions, vertices = voronoi_finite_polygons_2d(vor)
for region in regions:
    polygon = vertices[region]
    plt.fill(*zip(*polygon), alpha=0.4)
    plt.plot(points[:, 0], points[:, 1], 'ko', markersize=8)
plt.xlim(vor.min_bound[0] - 0.1, vor.max_bound[0] + 0.1)
plt.ylim(vor.min_bound[1] - 0.1, vor.max_bound[1] + 0.1)
city_bigmap.drawcoastlines()
city_bigmap.drawcountries()
city_bigmap.drawstates()
city_bigmap.drawrivers()

for i in range(1, len(long30)):  # for each coordinate until the last one
    x, y = city_bigmap(long30[i], lat30[i])  # get lat/long attributes for city bigmap
    if maxct == minct:
        themarksize = 4
    else:
        themarksize = 3.0 + (counts[i] - minct) / (maxct - minct) + 0.4
    city_bigmap.plot(x, y, color=dot_color, marker='o', markersize=themarksize)  # add marker to city bigmap
plt.title('Tax Bills Mailed from ' + cityname)
plt.savefig(cityname + '_bigmap.png')
```
